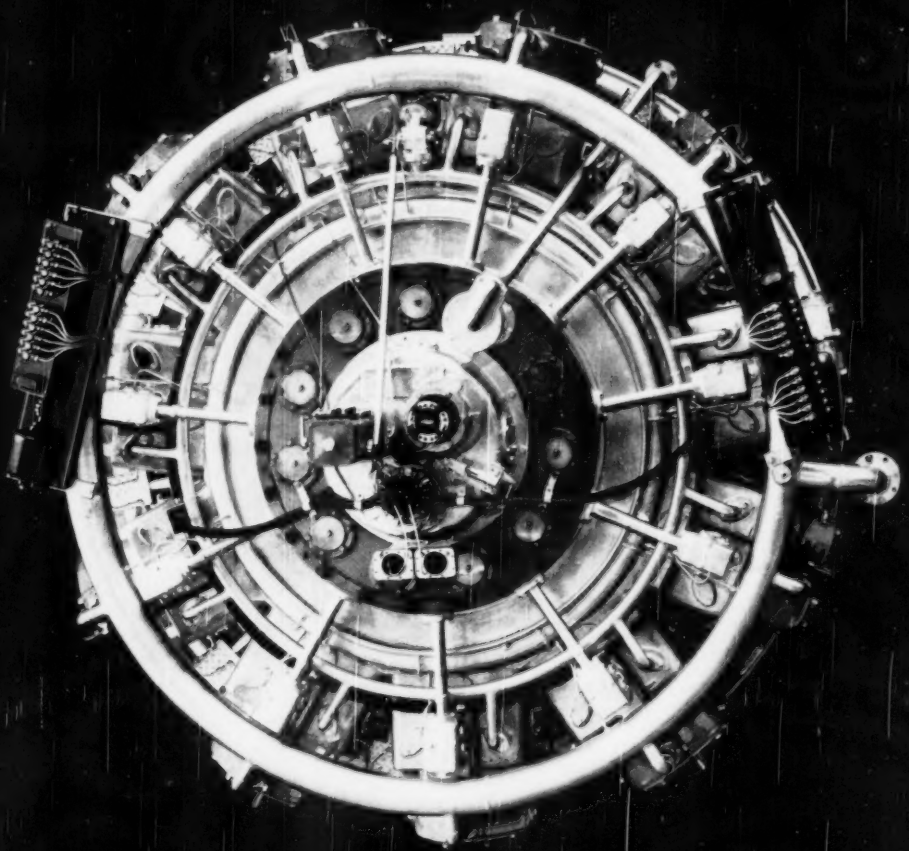
Diesel Power

& Diesel Transportation

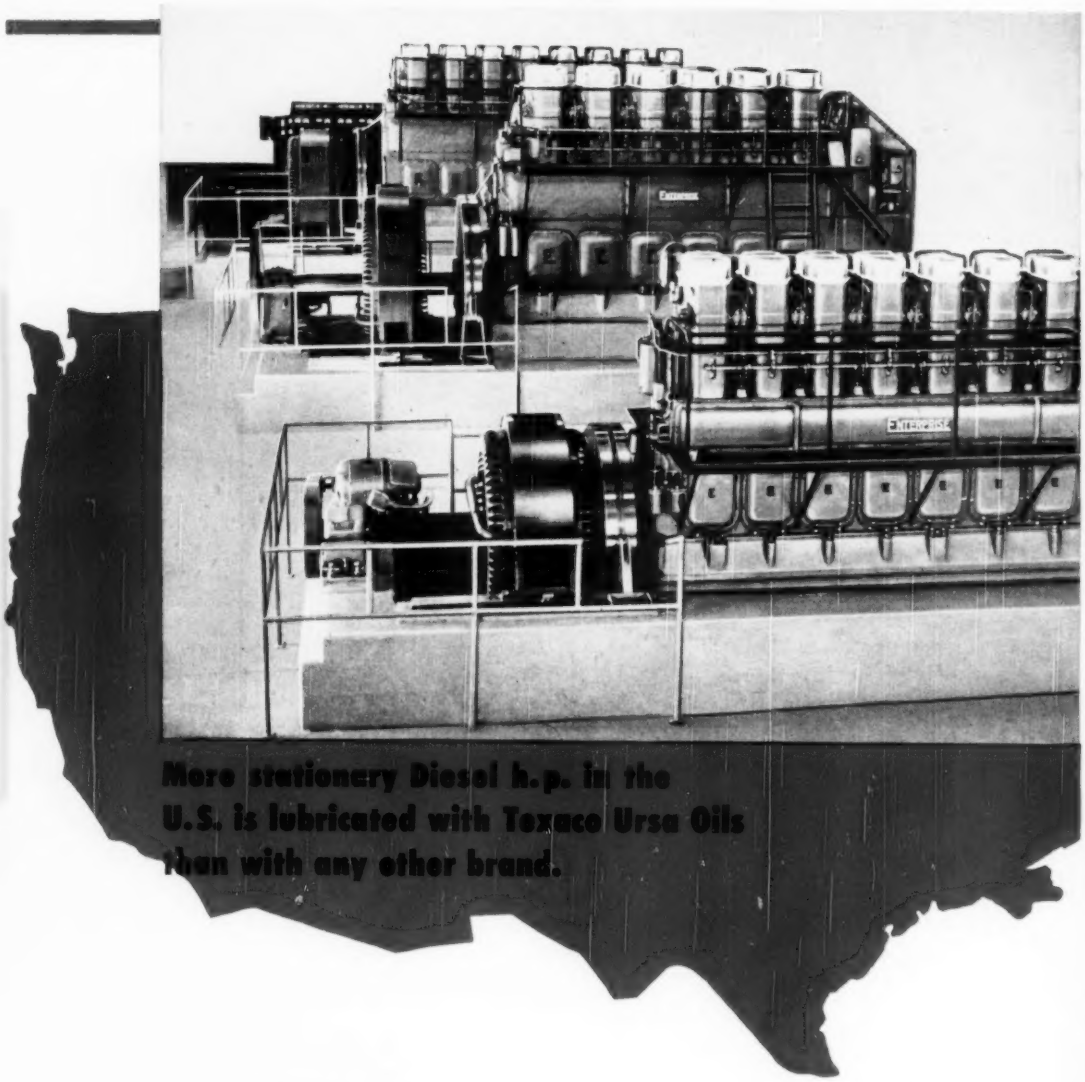


ALCOA'S POINT COMFORT WORKS

Our 28th Year

JULY, 1950

Better Compression



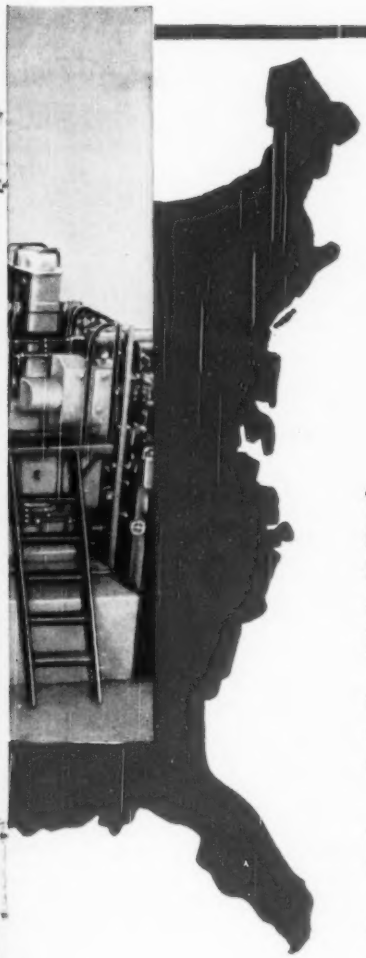
More stationary Diesel h.p. in the U.S. is lubricated with Texaco Ursa Oils than with any other brand.

TEXACO

TEXACO

DIESEL POWER and DIESEL TRANSPORTATION for July, 1950, Vol. XXVIII, No. 7. It is published monthly by Diesel Publications, Inc., Orange, Conn. Executive and Editorial offices 192 Lexington Ave., New York Inc. N. Y. Subscription rates: United States $4.00 per year, single issues 35c. Canada $4.00. Foreign, $5.00 per year. Entered as second class matter April 29, 1940 at the Post Office, Orange, Connecticut, under Act of March 3, 1879.

...Better Combustion



. . . and less fuel consumption when you lubricate Diesels with TEXACO URSA OILS

TEXACO URSA OILS are especially made to stand up under heat and pressure and to resist oxidation. They keep engines free of harmful carbon, varnish and sludge. Thus, valves stay active, ports open, and rings free for proper seal. Better compression and combustion, and lower fuel consumption result.

Maintenance costs, too, are lower, because *Texaco Ursa Oils* maintain their friction-fighting films . . . constantly guarding against wear and assuring longer life for bearings, pistons, rings, and cylinder liners.

There is a complete line of *Texaco Ursa Oils.* Leading Diesel engine manufacturers approve them, and operators everywhere use them for every type and size of Diesel engine.

Let a Texaco Lubrication Engineer work with you to bring down your Diesel operating costs. Just call the nearest of the more than 2,000 Texaco Wholesale Distributing Plants in the 48 States, or write The Texas Company, 135 East 42nd Street, New York 17, N. Y.

URSA OILS FOR ALL DIESEL ENGINES

120 NORDBERG

provide reliable uninterrupted power

in the WORLD'S LARGEST INTERNAL COMBUSTION ENGINE PLANT

★ ★ ★ ★ ★ ★

NORDBERG *Gas Burning Radials*
at Alcoa's Point Comfort Reduction Works
provide nearly 200,000 Horsepower
24 HOURS A DAY—365 DAYS A YEAR
to meet the full capacity demand

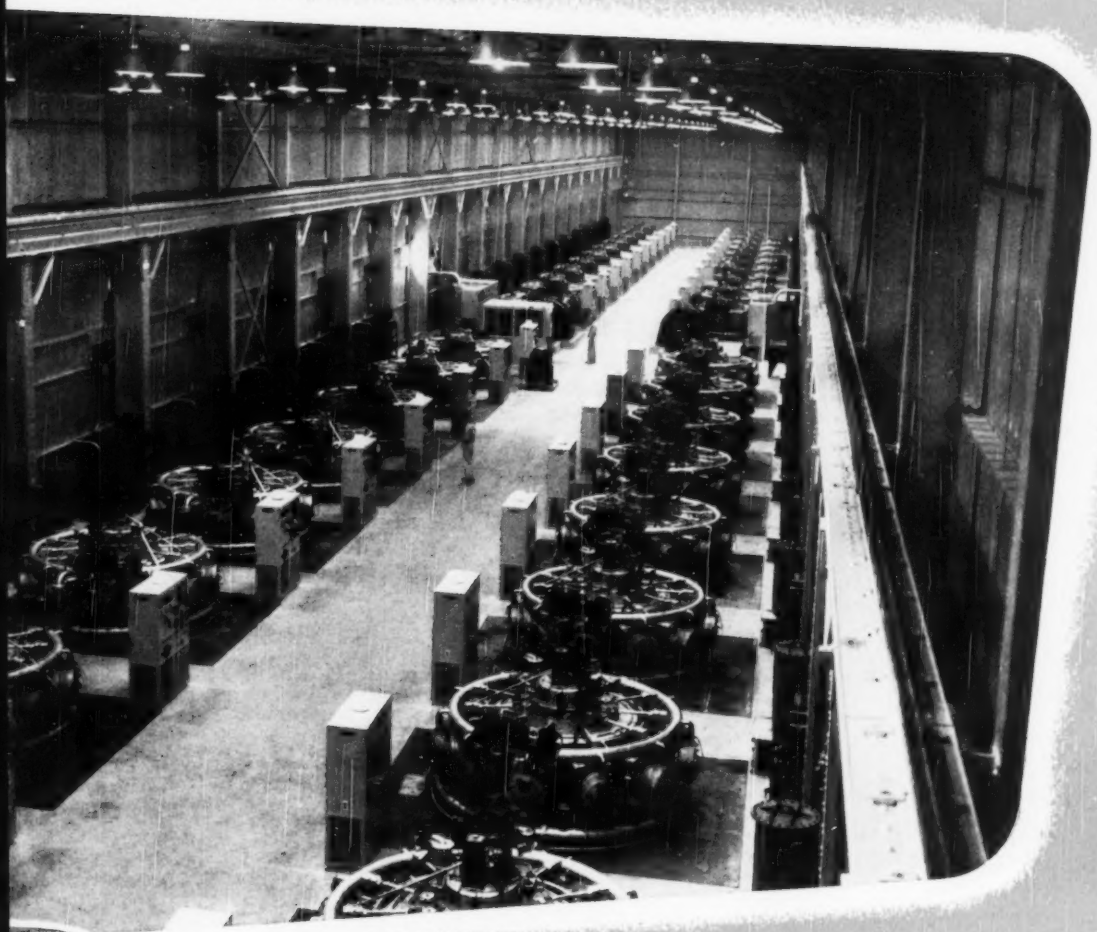
Important features of
NORDBERG *Radial* ENGINES

- LOWER INVESTMENT COST
- LOWER INSTALLATION COST
- LOWER OPERATING COST
- LOWER MAINTENANCE COST
- LESS SPACE REQUIRED
- **AVAILABLE THREE WAYS . . . as oil burning Diesels, as natural gas engines, or as Duafuel engines.**

Applicable for industrial and municipal power plants and central stations or wherever compact, economical, dependable power is required. *For full details covering Nordberg Radials, send for BULLETIN 172.*

P650

Radial ENGINES



IN planning the Point Comfort (Texas) Reduction Works, Aluminum Company engineers were confronted with the tremendous task of providing sufficient electric generating capacity to produce over 100,000,000 pounds of aluminum per year. By specifying 120 Nordberg two-cycle Radial Engine Generating Units as the solution to this huge power problem, Alcoa took advantage of these important economy factors:

(1) *Reduced investment cost* . . . engine-generating unit cost . . . installation cost (building size is 50% of usual requirements).

(2) *Reduced operating cost* . . . fuel cost . . . maintenance cost.

(3) *The experience offered by Nordberg as the producer of America's largest line of heavy duty internal combustion engines.*

This tremendous installation exemplifies the way in which Nordberg Diesel Engines, in sizes from 10 to 9600 hp., are used to provide dependable, economical power for stationary and marine requirements all over the world.

NORDBERG MFG. CO., Milwaukee, Wis.

BUSCH-SULZER
A DIVISION OF NORDBERG

NORDBERG
DIESEL ENGINES

Who Started Engine Builders Using ALUMINUM?

You did. Engine builders turned to aluminum when you and thousands of other diesel users demanded lighter, smaller, more powerful diesels. With aluminum, they have the weight of super-charger housings, crankcases and frames. In moving parts—like pistons, connecting rods, super-charger impellers—they lessen vibration and lower inertia with aluminum. And save *still more* weight.

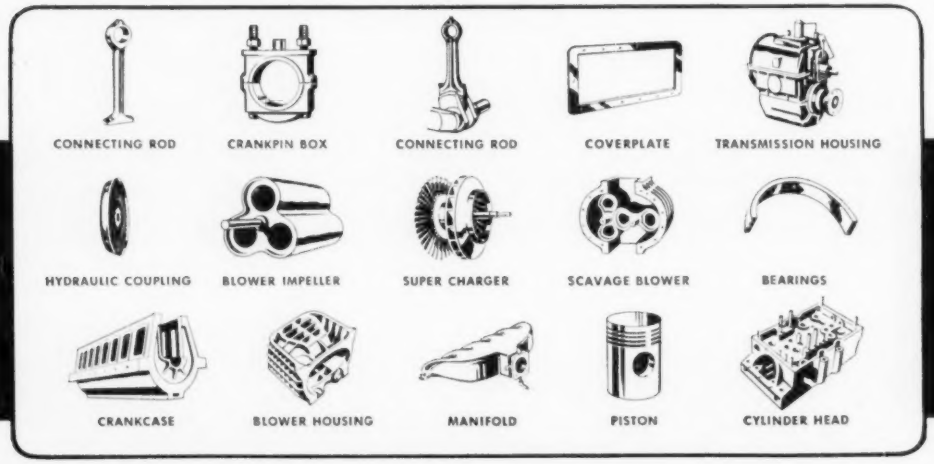
How was size reduced? By helping engines work harder. Aluminum lets pistons and rods move faster. Pistons and heads of aluminum can soak up the extra heat of higher mean effective pressures and piston speeds. Another way of saying aluminum makes engines lighter, smaller and/or more powerful.

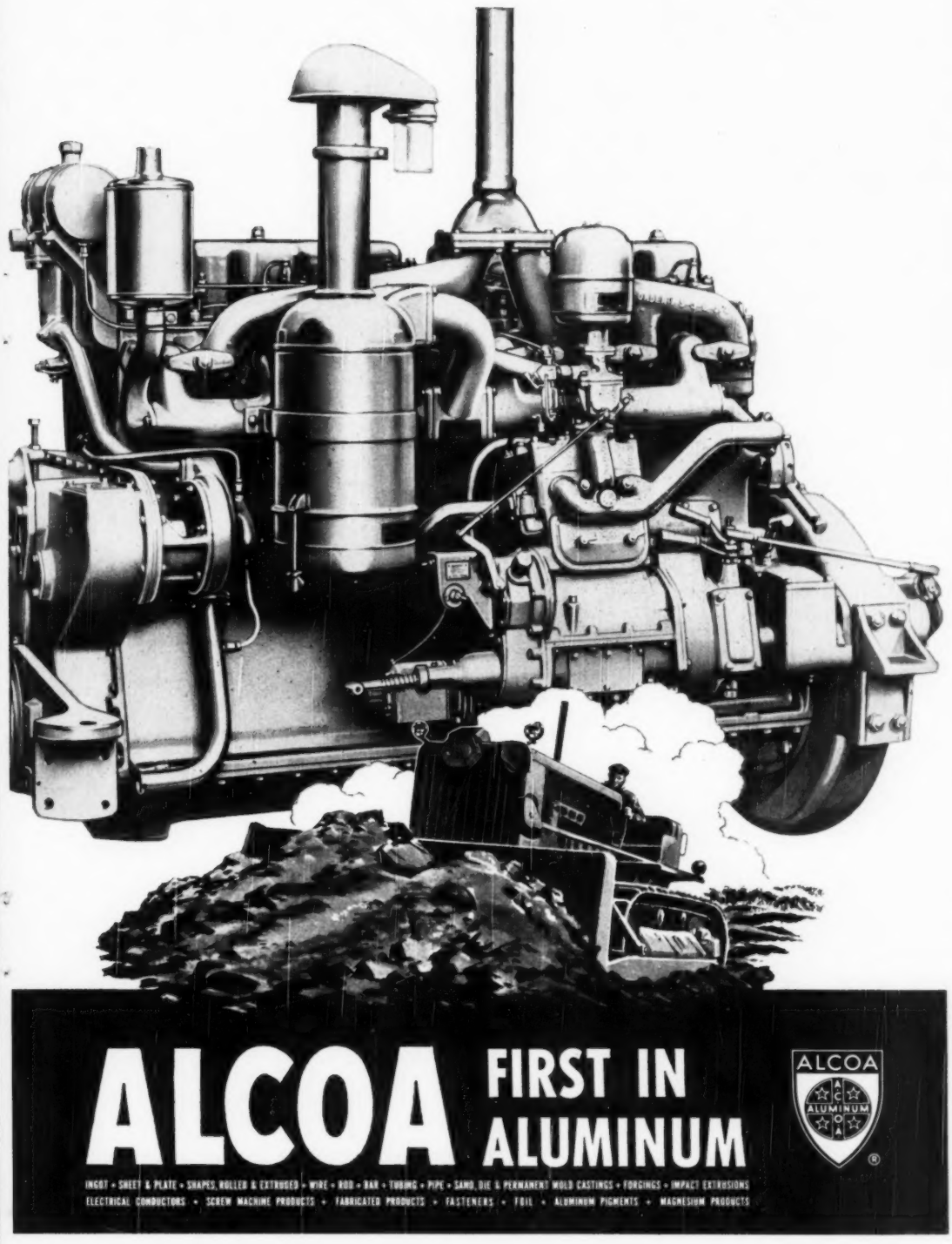
Then consider aluminum bearings. Solid metal. No hard backing to score expensive shafts. They rate highest in fatigue strength—highest in thermal conductivity—highest in strength at elevated temperatures. Additive oils don't corrode them—no inhibitors needed.

All of which adds up to more availability—better performance when you make sure your engine builder uses aluminum liberally.

IF YOU BUILD DIESEL ENGINES...

Alcoa supplies engine builders with semi-finished parts from 5 modern foundries, 2 forge shops, 2 die casting plants. Alcoa researchers have worked with engine builders for the past 25 years in developing lighter, smaller, more powerful diesels. For complete information, write: ALUMINUM COMPANY OF AMERICA, 2100G Gulf Bldg., Pittsburgh 19, Pa.



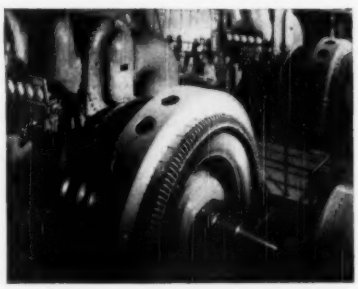

ALCOA
FIRST IN
ALUMINUM
ALCOA
ALUMINUM
INGOT • SHEET & PLATE • SHAPES, ROLLED & EXTRUDED • WIRE • ROD • BAR • TUBING • PIPE • SAND, DIE & PERMANENT MOLD CASTINGS • FORGINGS • IMPACT EXTRUSIONS
ELECTRICAL CONDUCTORS • SCREW MACHINE PRODUCTS • FABRICATED PRODUCTS • FASTENERS • FOIL • ALUMINUM PIGMENTS • MAGNESIUM PRODUCTS

AT YOUR SERVICE: *50 years*

High-quality generators at minimum cost . . . the natural result of 50 years of G-E generator-building experience

Quality that gives you the most for your generator dollar is the natural result of more than half a century of generator building . . . the result of skills developed by men like Charles Wahl.

A machinist for more than 40 years, Mr. Wahl learned his high standard of workmanship from men like his father, also a master machinist. Today he's passing his tradition of craftsmanship along to younger men . . . teaching them to build G-E quality into electric equipment. We're proud of Charles Wahl, and Mr. Wahl is proud to help us give you the service that's your right as a G-E customer.



Dependability and high operating efficiency are characteristic of every G-E synchronous generator . . . the result of more than 50 years' experience in development, manufacture, and application of synchronous generators. Performance records of thousands of these sturdy, efficient generators now on the job have made G.E. a "buy" word for purchasers of power-generation equipment. Apparatus Department, General Electric Co., Schenectady 5, N. Y.

Your Best Generator Buy...

# of know-how

GENERAL ELECTRIC

770-16

EATON

Zero-Lash

Registered U. S. Patent Office

HYDRAULIC VALVE LIFTERS

The Modern Method of Valve Actuation

Millions of Zero-Lash Hydraulic Valve Lifters and Zero-Lash adjusting units—designed and developed exclusively by Eaton Manufacturing Company—have gone into leading automotive, aircraft, tractor, marine and industrial engines in the last 17 years. They have contributed:

- Freedom from Tappet Adjustments for the Life of the Engine.
- Accurate Valve Timing and Perfect Seating at All Engine Speeds and Temperatures.
- Longer Life for Valves and Seats.
- Silent Valve Train Operation.

Since 1932 Eaton Engineering Departments have been engaged in constant research and development of improved designs and of new wear-resistant materials which make today's—and tomorrow's—Zero-Lash Hydraulic Valve Lifters the truly modern method of valve actuation.

EATON MANUFACTURING COMPANY

CLEVELAND, OHIO

Saginaw Division

9771 French Road · Detroit 13, Michigan

PRODUCTS: SODIUM COOLED, POPPET, AND FREE VALVES • TAPPETS • HYDRAULIC VALVE LIFTERS • VALVE SEAT INSERTS • ROTOR PUMPS • MOTOR TRUCK AXLES • PERMANENT MOLD GRAY IRON CASTINGS • HEATER-DEFROSTER UNITS • SNAP RINGS • SPRINGTITES SPRING WASHERS • COLD DRAWN STEEL • STAMPINGS • LEAF AND COIL SPRINGS • DYNAMATIC DRIVES, BRAKES, DYNAMOMETERS

STANDARD ENGINEER'S REPORT

RPM DELO

TEST DATA

LUBRICANT *RPM Delo Supercharged Lubricating Oil*

UNIT *Caterpillar Diesel-D17000-V8 Cyl.*

CONDITIONS *Cont. High load-actual field oper.*

FUEL *Commercially available Diesel Fuel*

TEST PERIOD *4 months*

FIRM *Homer Jones Ranch, Chandler, Ariz.*

Stopped all ring sticking where ordinary oil failed!

AFTER ONLY 625 HOURS operation on an ordinary heavy-duty type oil, an engine pulling 90% of full load rating had 39 stuck rings—only 9 of its 48 rings were free and several were broken. There were heavy lacquer and carbon deposits in ring grooves and on piston-skirts, as indicated by this unretouched photograph of one of the pistons. Besides stuck rings, note clogged oil-return holes and oil rings.

OPERATED 1582 HOURS — more than twice as long — on RPM DELO Supercharged-2 Lubricating Oil, the same engine, running under the same load and fuel conditions, stayed efficient and clean, as this unretouched photograph shows. At the end of test all 48 rings were free, with no piston-skirt deposits. Ring-groove deposits were 50% less. Note how RPM DELO Supercharged-2 kept oil-return holes open.

REMARKS: RPM DELO Supercharged-2 Lubricating Oil is one of four grades in the RPM DELO Oil line. It solves operating problems in both Diesel and gasoline engines, especially where load conditions are extreme.

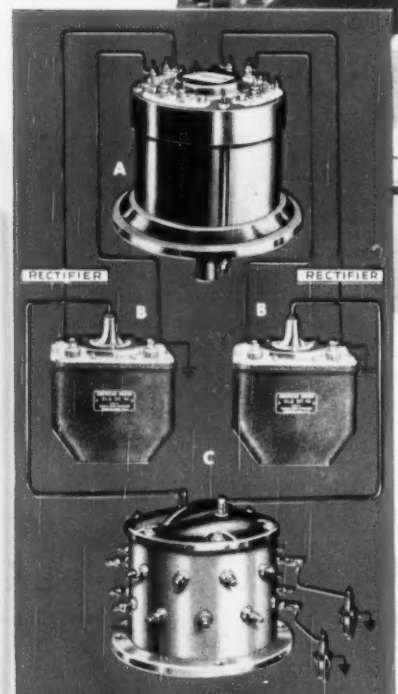
Its detergent prevents carbon and lacquer deposits on all parts, even with high sulphur-content fuels.

RPM DELO Supercharged-2 Oil sticks on hot and cold surfaces — reduces wear under the heaviest loads. (Cylinder-wear averaged only 0.0014 inches per 1000 hours with RPM DELO Supercharged-2, while with the ordinary oil it was 0.0043 inches — three times greater.) RPM DELO Supercharged-2 Lubricating Oil also contains special compounds that resist oxidation and sludging, prevent bearing corrosion and internal rusting, and stop foaming.

FOR MORE INFORMATION about the proper grade of the new RPM DELO Oils to fit your particular requirements, or the complete line of RPM Lubricants, and the name of your nearest "RPM" Distributor, write or call any of the companies listed below.

STANDARD OIL COMPANY OF CALIFORNIA • San Francisco
THE CALIFORNIA OIL COMPANY • Barber, N. J., Chicago
STANDARD OIL COMPANY OF TEXAS • El Paso, Texas
THE CALIFORNIA COMPANY • Denver, Colorado

View of one of the three engine rooms at the Point Comfort, Texas reduction plant of the Aluminum Company of America. Each room houses forty Nordberg 11-cylinder radial gas engines connected to 1150 KW DC generators and using special ignition equipment manufactured by American Bosch.



The special low-tension magneto-type generator (A) sends suitably spaced electrical impulses to the twin transformers (B-B) without use of cams, breakers, brushes, or slip rings. These powerful pulses are stepped up in voltage by the heavy transformers to the high potential required by the two sets of spark plugs served through the double-docked distributor (C).

Experience has shown that this type of ignition system is assured of extraordinarily long operating life.

A Notable Advancement *in Ignition*

The unusual ignition equipment for this magnificent installation was developed and perfected by American Bosch for Nordberg, from initial designs by Alcoa based on wartime experience in similar plants.

Largest independent producer of Diesel fuel injection equipment in the United States, American Bosch has always produced electrical ignition equipment too . . . is constantly working to develop new ideas in either field that will advance the internal combustion engine.

The engineering knowledge and manufacturing ability required to develop and produce equipment such as that shown here are reflected in every product that bears the name American Bosch.

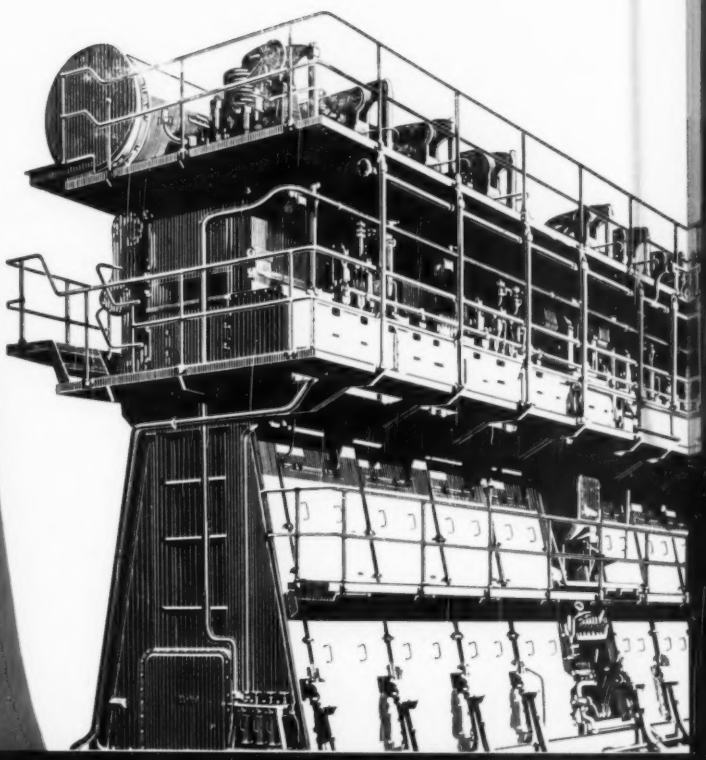
American Bosch

Dependable Fuel Injection for the Diesel Industry

AMERICAN BOSCH CORPORATION, SPRINGFIELD 7, MASS.

Magnetos · Generators · Voltage Regulators · Ignition Coils · Electric Windshield Wipers · Diesel Fuel Injection Equipment

B&W
Diesel Engines



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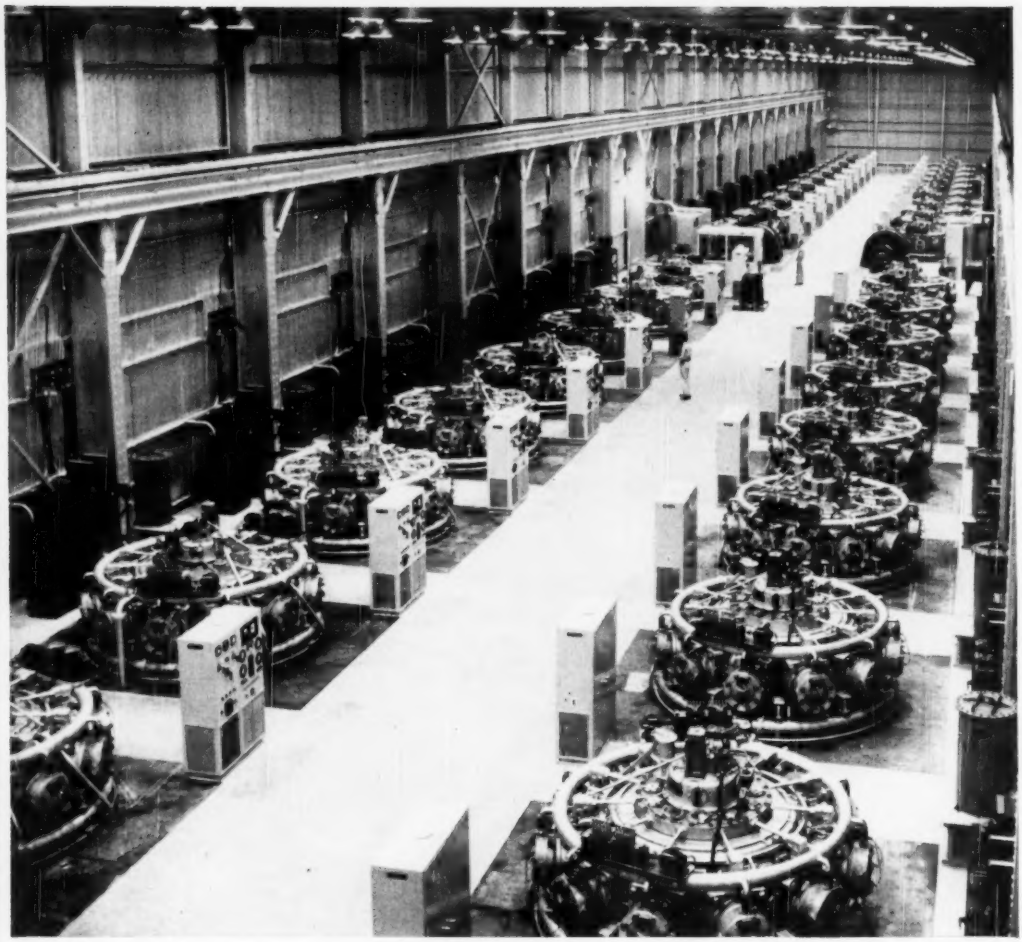
IN
FIRST UNITED STATES
INTERNATIONAL TRADE FAIR
CHICAGO
AUGUST 7-20, 1950

BURMEISTER & WAIN

COPENHAGEN DENMARK

SPARE PARTS AND SERVICE IN U.S.A.: BURMEISTER & WAIN AMERICAN CORPORATION, WHITEHALL BUILDING, BATTERY PLACE, NEW YORK



SEALED POWER PISTON RINGS are used exclusively in the new Point Comfort, Texas plant of the Aluminum Company of America. This is the world's largest gas engine plant, developing 192,000 horsepower from 120 radial type Nordberg engines. The above photograph shows one of the three lines of 40 engines each.

SEALED POWER CORPORATION
MUSKEGON, MICHIGAN

Sealed Power

PISTON RINGS · PISTONS
CYLINDER SLEEVES

DELCO-REMY
ON THE DIESELS

GM Diesel mobile powerplant with Delco-Remy cranking motor.

DIESELS ON THE JOB

Mobile powerplants for circus lighting and for numerous other applications are now largely Diesel-powered.

On the Diesels, as in the application shown, you'll usually find Delco-Remy electrical equipment.

Diesel plus Delco-Remy is a combination well known for *reliable performance.*

UNITED SERVICE MOTORS

DELCO-REMY—A UNITED MOTORS LINE
Service Parts and Delco Batteries
Available Everywhere Through
UNITED MOTORS DISTRIBUTORS

Delco-Remy
DIVISION, GENERAL MOTORS CORPORATION
ANDERSON, INDIANA

DELCO-REMY • WHEREVER WHEELS TURN OR PROPELLERS SPIN

Fountain of Youth...

Ponce de Leon found Florida, on Easter Sunday, 1513. He was looking for a legendary island called Bimini, where he could restore his youth and vigor in a magic Fountain of Youth.

for

DIESEL Liners

Had he found what he was looking for, old Ponce de Leon would be one of our customers today. He'd have been quick to see VANDERLOY M and PORUS-KROME,* as a veritable "Fountain of Youth" for diesel liners.

Even liners ready for the scrap pile get back their original size in a way that makes them work better, last much longer and lets them be renewed again and again.

Now that's just what the old Spanish explorer wanted for himself. Worn to a nub, from sailing with Columbus and then working up to govern the Indies, about all he had left was the courage of his convictions.

But he let himself be convinced by a legend. You, of course, want only facts. The kind the Van der Horst process has been piling up, in thousands of hours of actual service, prove that diesel liners need never wear out.

Why not take advantage of this way to cut your operating costs?

We'll gladly show you how—today.

**PORUS-KROME is a dense, hard, wear and corrosion-resistant chromium, produced by the Van der Horst Corporation of America, and which gives working surfaces an infinite number of tiny oil-retaining reservoirs for perfected lubrication.*

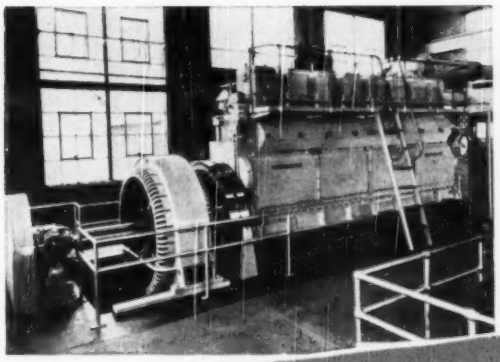
VAN DER HORST CORPORATION OF AMERICA • OLEAN, N. Y.

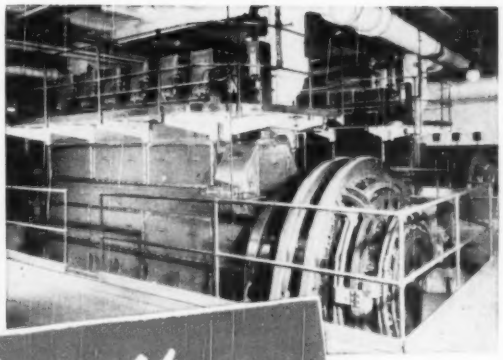
U. S. PATENTS 2,048,578, 2,314,604 and 2,412,698

PORUS - KROME

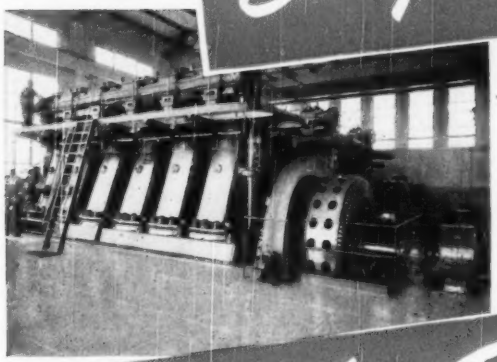
Good for the Life of your Engines

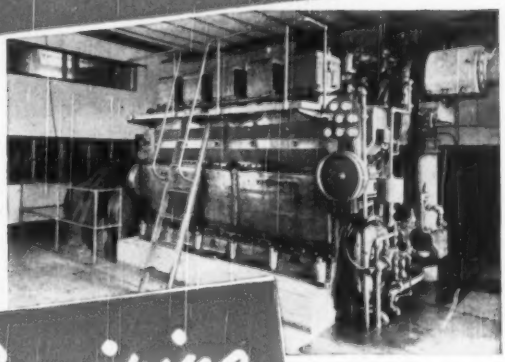
VAN DER HORST





Every One New...





Every One Requiring

ADVANCED LUBRICANTS

DIESEL UNITS like these new "big babies" are a vitally important investment to any plant. They deserve and demand only the finest lubrication. Start them off with the right type and grade of oil and they will operate efficiently with little maintenance expense.

Take full advantage of the knowledge and experience of the Cities Service Lubrication specialists. These men are fully informed on the lubrication requirements of all the latest models. Their advice and recommendations can contribute to longer years of use, dependable and economical performance.

Write Cities Service Oil Company, Room 630, Sixty Wall Tower, New York 5, New York.

HELPFUL NEW BOOKLET—FREE!

We have a new 64 page manual entitled "Diesel Engine Lubrication." Write for your free copy of this fact-filled lubrication guide today.

CITIES SERVICE

HILCO

FOR ALUMINUM COMPANY OF AMERICA'S NORDBERG ENGINES...

Those who know select **HILCO**

Whether you operate 100 or 100,000 h.p. there is a HILCO that will best take care of your gas or diesel engine lubricating oil maintenance—proven performance and service for one quarter century.

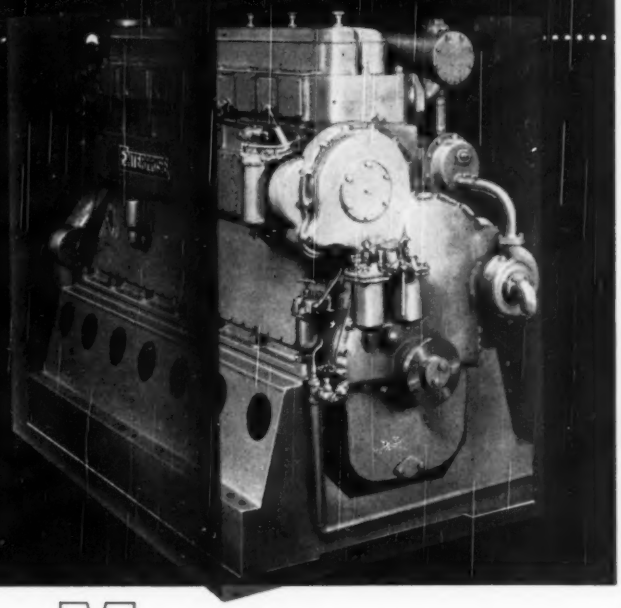
A trained HILCO field engineer will gladly survey your oil maintenance problem and make recommendations with no obligation on your part.

★Before you specify or buy lubricating or fuel oil filters, reclaimers, purifiers or conditioners, send for FREE HILCO literature.

THE HILLIARD CORPORATION, 120 W. FOURTH ST., ELMIRA, N. Y.

engineered to bring you the finest in medium speed

packaged diesel power



. . . the New ENTERPRISE M SERIES Stationary Diesels

If you want 68 to 240 BHP, you'll get more for your money with an Enterprise 3, 4, or 6 cylinder M Series Diesel

- 8" bore x 10" stroke
- Compact, light weight
- Easy starting, air or electric
- Operate on wide variety of low cost fuels
- Extremely low fuel consumption
- Smooth, quiet, clean operation
- Front and rear end power take-offs

Write for new Enterprise M Series Bulletin No. M-16, or call your nearest Enterprise office for complete information.

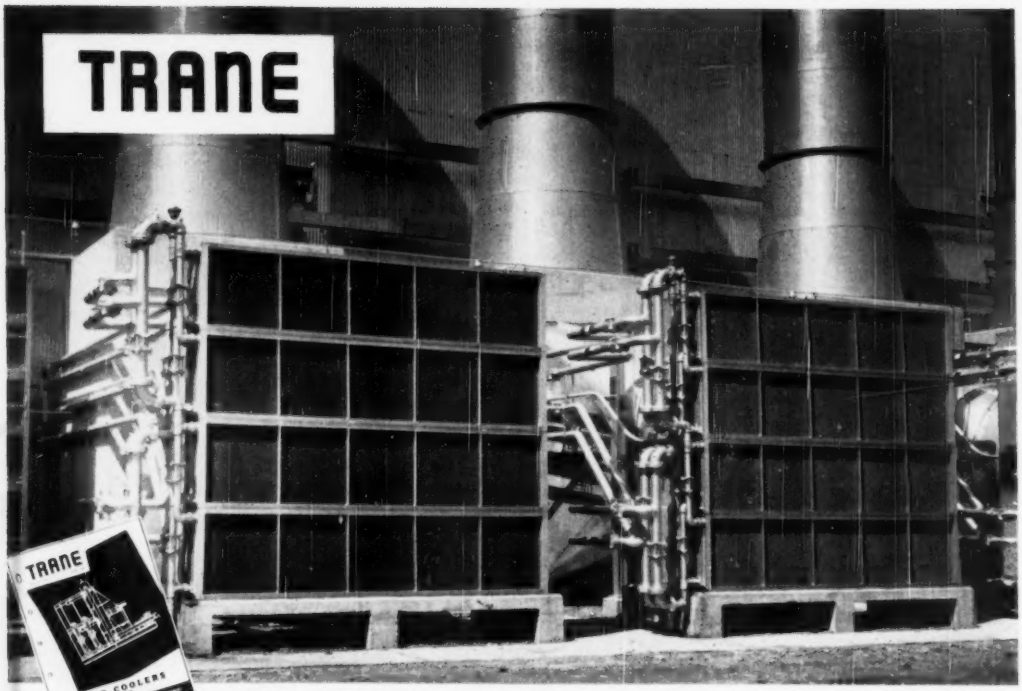
Everything you want in efficient stationary power is wrapped up in the all-new M Series packaged power plants. Designed and developed to meet the demand for tough and continuous operation at medium speeds, these completely self-contained diesels in 3, 4 and 6 cylinder models are now available for the most economical solution to your industrial power needs. Small, compact, light weight, portable if desired, these units deliver 68 to 240 BHP at conservative speeds of 450 to 750 RPM. They are WORK engines, capable of thousands of hours in demanding service, at low cost, with minimum maintenance and servicing requirements. When you compare, feature for feature, you're sure to make your next diesel a medium speed, high capacity Enterprise M engine—for years of the smoothest power you've ever enjoyed.

ENTERPRISE ENGINE & FOUNDRY COMPANY

18th & Florida Streets, San Francisco 10, California Offices in Principal Cities

Enterprise STATIONARY Diesels

TRANE



Two of the 120 Trane Fluid Coolers used by Alcoa at Point Comfort, Texas, to dissipate heat from huge radial diesel engines.

New Cost-Reducing Method of Air-Cooling Gases & Liquids

The new Trane dry type Fluid Coolers cool either liquids or gases in a closed system using air as the cooling medium.

Available in two models and a complete range of sizes, the application of these versatile units is limited only by the ranges of air cooling and the consistencies of liquids to be cooled.

Solving Alcoa Engine Cooling Problem

At the Point Comfort, Texas, reduction plant of Aluminum Company of America, 120 Trane Fluid Coolers solved a difficult cooling problem created by Alcoa's 216,000 h.p. radial internal combustion engines.

Similar units are also economical problem-solvers for cooling jacket water and lubricating oil from diesel, gasoline or gas engines, water used with shell-and-tube heat exchangers, quenching oil; gases such as natural gas, carbon dioxide, propane, freon and other refrigerants. The list of applications is endless.

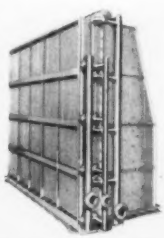
Complete data for selection, specification and installation of Trane dry type Fluid Coolers is contained in Bulletin DS-395.

THE TRANE COMPANY...LA CROSSE, WIS.

EASTERN MANUFACTURING DIVISION, SCRANTON, PA.

Manufacturing Engineers of Heating, Ventilating and Air Conditioning Equipment—Unit Heaters, Convector-radiators, Heating and Cooling Coils, Fans, Compressors, Air Conditioners, Unit Ventilators, Special Heat Exchange Equipment, Steam and Hot Water Heating Specialties ... IN CANADA, TRANE COMPANY OF CANADA, LTD., TORONTO.

The standard line of Trane Fluid Coolers consists of the EC series—14 sizes, fan diameters from 18" to 120" (left and right). The GC series—8 sizes with fan diameters from 72" to 144".

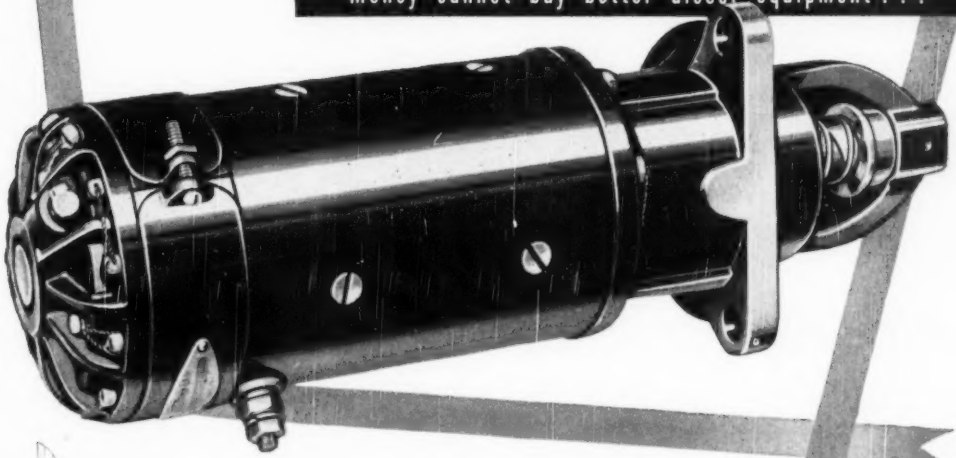


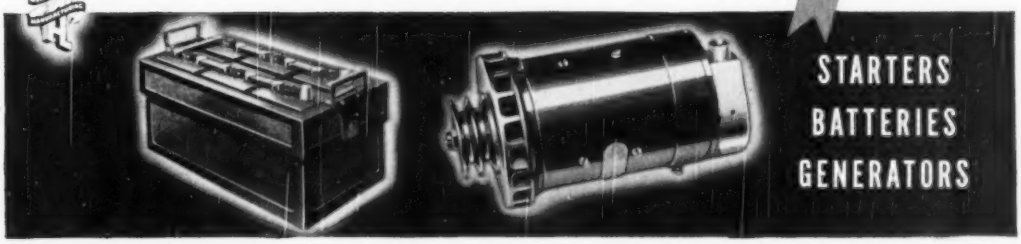
Switch to AUTO-LITE diesel equipment

● The result of Auto-Lite's 38 years of automotive electrical experience, Auto-Lite Diesel systems are complete from generator to voltage control to battery to starter. The dependability of Auto-Lite electrical units in service has made Auto-Lite the world's largest independent manufacturer of automotive electrical equipment. Engineers and executives are invited to consult with us on Diesel cranking and generating equipment.

THE ELECTRIC AUTO-LITE COMPANY
Sarnia, Ontario Toledo 1, Ohio

Money cannot buy better diesel equipment . . .





STARTERS
BATTERIES
GENERATORS

Alcoa Power

world's largest internal combustion plant

Alnor Protected

Here you see one-third of the engines that comprise the world's largest internal combustion power plant—120 Nordberg engines in all, totaling 192,000 hp.

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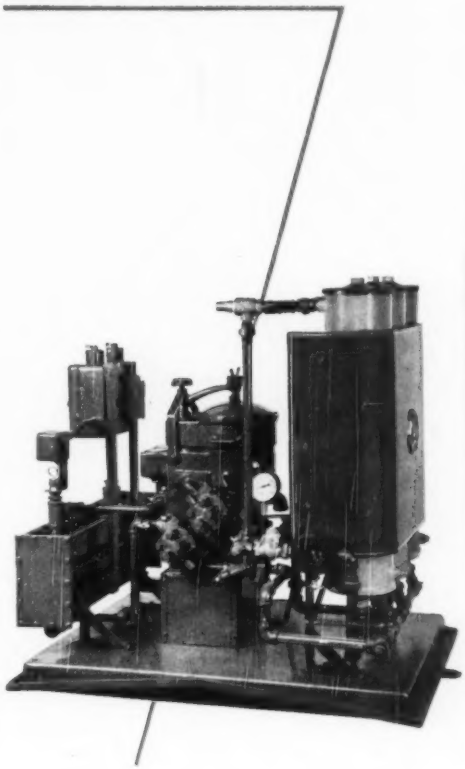

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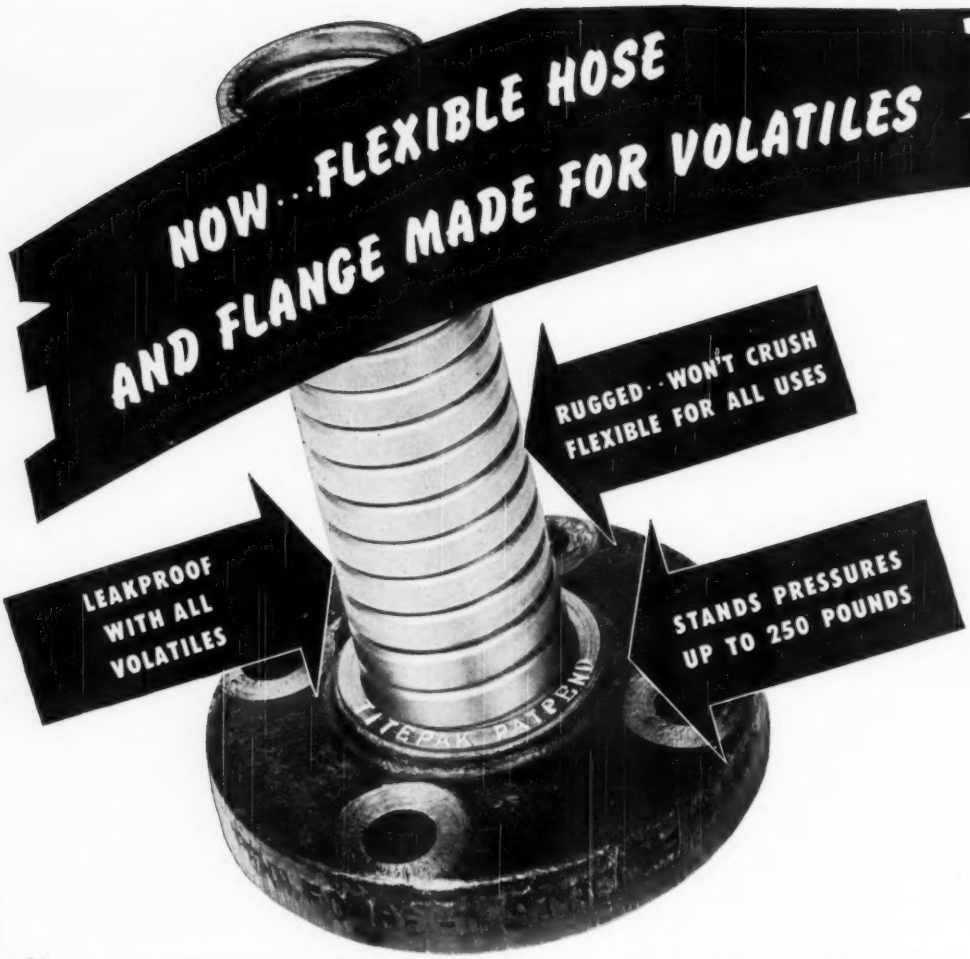

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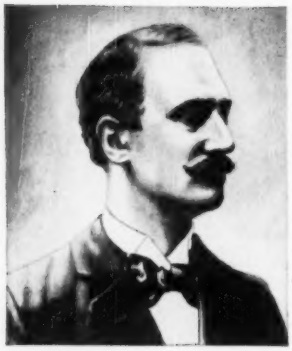

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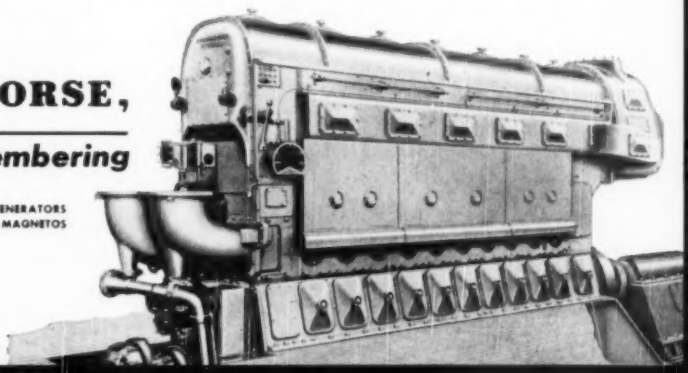

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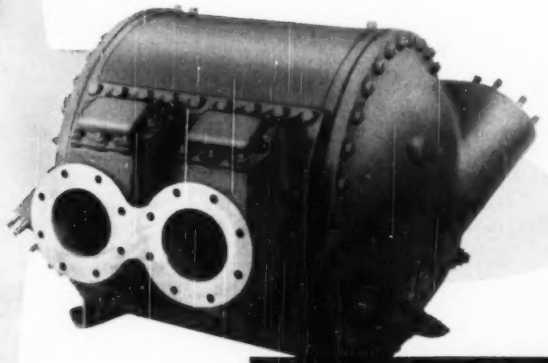

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Vol. 28 No. 7 July, 1950

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View of the Nordberg radial engine. One hundred and twenty of these unique engines were installed in the Point Comfort works of the Aluminum Company of America. This plant is described in the feature article of this issue.

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Alcoa's Point Comfort Works 38

A description of the largest internal combustion plant in the world owned by the Aluminum Company of America and located at Point Comfort, Texas. The plant will be used for aluminum production and is the first commercial application of the Nordberg radial engine.

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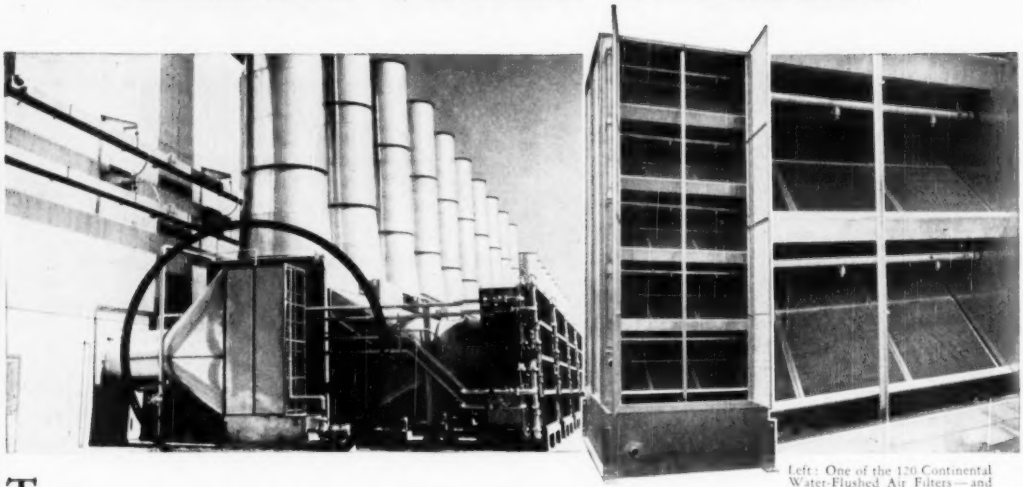

Left: One of the 120 Continental Water-Flushed Air Filters—and (right) a close-up of the revolutionary "Ezwash" cells.

The photo above shows one of 120 Continental Water-Flushed Air Filters—probably the largest installation of such equipment ever made—now handling 4,200,000 CFM for the Aluminum Company of America power plant at Point Comfort, Texas.

These 120 Continental Water-Flushed Air Filters have a capacity of 35,000 CFM each. They clean all the air for this giant plant—for 120 1,600 HP Nordberg radial gas engines, as well as for all electrical ventilation and comfort cooling.

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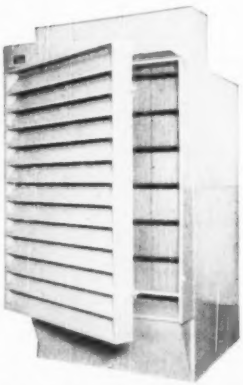

An 11,000 CFM Continental Automatic Self-Cleaning Air Filter—one of 29—used on Cooper-Bessemer GMV-10 Gas engine-driven Compressors by Transcontinental Gas Pipe Line Corp., at Stockridge, Ga.

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Editorial:

Gas and Liquid Fuels

THIS issue is largely devoted to a description and details of Alcoa's new Point Comfort plant. Its 120 engines—totaling 192,000 hp.—make it the largest internal combustion plant in the world, deposing a plant for similar purposes, built by Alcoa during the war and now operated by the Reynolds Metals Company.

Note the phrasing of the title — "largest internal combustion plant . . . " — for this plant uses spark ignition gas engines and the older plant at Jones Mills, Arkansas, uses 50 Cooper-Bessemer spark ignition engines and 18 Nordberg gas-diesels. As pointed out in recent editorials, the choice of fuels and engines to burn them is a matter of economics. Fuel cost at any specific location may be the deciding factor even though the diesel is still tops in the matter of thermal efficiency.

As the areas in which comparatively cheap gas is available are expanded, there will be a noticeable effect apparent in the engine business. It also follows that there will be repercussions in the petroleum industry.

Probably the first detailed study to be disclosed publicly on the present and future status of natural gas in relation to liquid fuels was presented by Mr. Albert J. McIntosh, an executive of the Socony-Vacuum Oil Company, New York, before the Western Petroleum Refiners Association. Remember that such of his remarks as are reported here cut across the entire petroleum industry and hence do not apply specifically to diesel fuels.

He feels that competition offered by natural gas will apply a "strong brake" to the prolonged upward trend in the use of petroleum fuel oils and kerosene. Total domestic consumption and exports of petroleum products are expected to increase during the next three years but this economist estimates that sales in 1953 may only be one per cent above the present total.

New supplies of natural gas are expected to provide the balance of the fuel required. After converting the gas into an equivalent oil industry unit of measurement, Mr. McIntosh predicts that natural gas, in three years, will provide an equivalent 518,000 bbl. per day. This is figured on the basis of an additional 283,000 bbl. in 1951, 166,000 in 1952 and 69,000 in 1953.

The nation's oil industry faces an estimated demand this year for about 2,748,000 bbl. daily. Mr. McIntosh expressed the belief that only half of the anticipated gas usage will displace liquid fuels (roughly, five per cent of the demand) with the balance displacing coal. It is expected that in the oil market there will be an increase in the use of distillate and fuel oils that will be largely offset by the losses in sales of residual fuels and kerosene.

In the face of this, Mr. McIntosh advises refiners to prepare to obtain "new all-time high yield of distillate fuel oils, particularly diesels and gasoline", from each barrel of crude oil.

Our concern lies in applying these predictions to determine the effect on the diesel fuel situation. Demand for the disillates will undoubtedly increase. The expected addition of some ten million horsepower per year, with a good portion in mobile service, will not all be able to use natural gas although propane may apply in the case of trucks and buses.

Demands for the heavier diesel fuels may be retarded as some plants convert and new plants install gas burning engines. New plants installed where gas is unavailable or uneconomic could well offset any loss, resulting in little change one way or the other.

This leaves the bunker fuels, a type not very widely used in diesels. In meeting the demands for distillates, the residuals become an incubus on the refiner and *must* be disposed of if only from the point of view of storage. One opinion is that the increased quantities resulting from losses to gas and high distillate production will be absorbed in the expansion of present power facilities. Research into new uses will also help to maintain the demand. In addition, increased gas prices, as in the earlier case of diesel fuels, could alter the whole economic structure.

In short, the five per cent displacement predicted should not have any drastic effect on the diesel fuel picture. There is bound to be some change and reshuffling, but that is nothing new to our economy.

Zallea Expansion Joint News

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Expansion Joint of the Month

The "Why" of Lateral Movement

WHEN ACTIONS SPEAK LOUDER THAN WORDS

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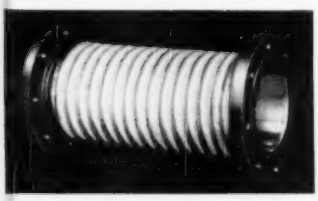

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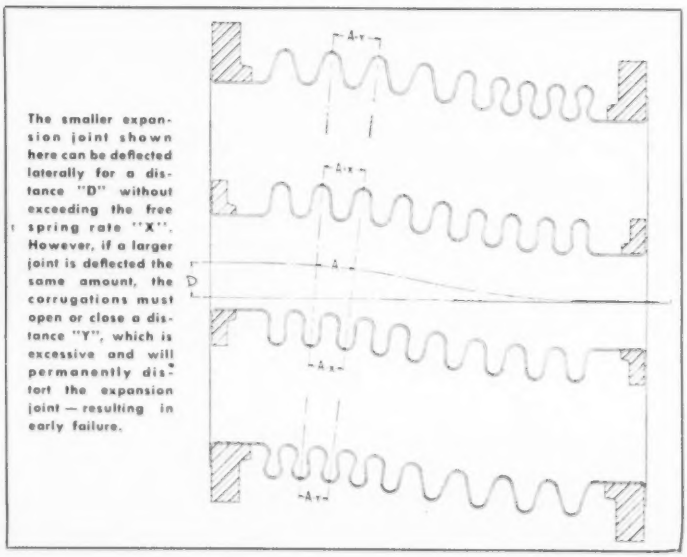
THE ordinary corrugated bellows of the past has not been very satisfactory for applications requiring lateral deflection, i.e., at right angles to the axis of the joint. This was due to the fact that very little study has been given to the manner in which an expansion joint is stressed when subjected to lateral movement. The tendency has been to assume that a corrugated joint could be displaced laterally some nominal amount such as $\frac{1}{16}$" or $\frac{1}{8}$" for each corrugation. This fallacious assumption has resulted in considerable overstressing and early failure of the joint.

Lateral Displacement Two Ways

There are two ways in which an expansion joint can be subjected to lateral displacement. The first is by angular rotation in which one flange remains fixed and the other flange is rotated out of parallel with the other. This condition is unusual and only occurs when expansion joints are used in pairs. The second is the usual case in which an expansion joint is *offset* laterally, while the flanges remain parallel. If a corrugation is compressed or stretched without stressing the metal beyond the elastic limit, it will always return to its original shape. The amount that a single corrugation may be displaced without exceeding the elastic limit is called the "spring rate" per corrugation, and depends on the thickness of metal and the shape and depth of the corrugation. In lateral movement, it is highly desirable that all corrugations function within the elastic limit so that distortion will be minimized and high stresses will not be developed in individual corrugations.

"Spring Rate" Is Important

When an expansion joint is displaced laterally, it assumes the shape of a simple offset bend and the corrugations on the outside of the bend open, while those on the inside close. The amount of this opening and closing should not exceed the "spring rate". As more corrugations are added, more lateral deflection can be absorbed. However, as the diameter of the joint is increased, the lateral deflection which can be absorbed per corrugation is reduced. Thus it is seen that if the rule of thumb formula, such as $\frac{1}{8}$" lateral deflection per corrugation, is applied, the larger joints would have to be excessively distorted to permit such lateral movement. Such joints would fail in short time due to abnormally high shear stresses.



The smaller expansion joint shown here can be deflected laterally for a distance "D" without exceeding the free spring rate "X". However, if a larger joint is deflected the same amount, the corrugations must open or close a distance "Y", which is excessive and will permanently distort the expansion joint — resulting in early failure.

+ HIGHLIGHTS +

● Almost half of the 1,500,000 lbs. of iodine used in America every year comes from oil wells.

● The three millionth farm to get power from the REA was connected recently. A great many REA plants are diesel installations.

● Receipts from special petroleum taxes on lubricating oil amounted to $18,419,490 for the first three months of 1950.

● The biggest size of seamless steel pipe, used mostly for pipe lines, is two thousand times the diameter of the smallest size of tube, used for hypodermic needles.

● In the latest *Vancoram Review*, publication of the Vanadium Corporation of America, is contained a data sheet on Vanadium steels and irons for diesel applications.

● A 2500 hp. gas turbine locomotive will shortly go into service on the Western Region of British Railways. The locomotive was originally ordered in 1946.

● Add to the government's store of items subject to price supports—tung nuts, soy beans, etc., the Lespedeza seed. This is defined as a form of clover on which $144,089 was loaned up to the first of the year.

● Cities and towns in New York State will have to spend over $400 million in the next ten years to clean up their sewage. Looks like a good market for diesel engines in sewage disposal plants.

● *The Oil Engine and Gas Turbine*, a British publication, has published in their May issue figures for 1948 and 1949 covering production and export figures for internal combustion engines. This data was not previously available.

● Trucks in this country haul more than 90 billion ton-miles a year.

● The U. S. oil industry has produced 63 per cent of all the world's petroleum.

● Recent statistics show that the average working citizen cannot call his pay his own until he has worked for 61 days.

● A five chime air whistle has been installed on the "New Columbian" train of the B & O which has a "softer and more melodious tone than the old familiar diesel air horn".

● Nearly a third more people have jobs today than did only 10 years ago. Last year close to 60 million persons had civilian jobs, compared with 46 million in 1939.

● At the end of last year, crude oil reserves in this country totaled 24,649,439,000 barrels and natural gas liquid reserves totaled 3,729,012,000 barrels.

● By the end of this year, the Chicago & North Western Railroad will have almost three times the number of diesel freight locomotives that it had in service at the beginning of 1949.

● The Atlantic Coast Line has recently published a book containing some "Fragments of Its History During Over Half a Century". Written by Champion Med. Davis, it gives some of the highlights of the road's history.

● A magnetic fluid clutch and magnetic amplifiers for motor and generator control have been developed under Navy contract by Vickers' Electric Division in St. Louis. This constitutes the first commercial production of the clutch recently developed by the Bureau of Standards.

● Steel accounts for 70 to 80 per cent of the weight of modern diesel locomotives.

● In the U. S. there are more than eight million motor trucks and trailers, more than half the trucks and trailers in the world.

● There are about 20,000,000 tons of steel rails in use in the United States over which nearly three billion revenue tons are hauled each year.

● Buffalo's International Railway Company will substitute 45-seat diesel powered buses on the city's six remaining streetcar lines with conversion to be completed by Oct. 1.

● By the use of permanent magnets which close the door and keep it closed, GE has eliminated the latch from refrigerator doors. A foot pedal opens this marvel.

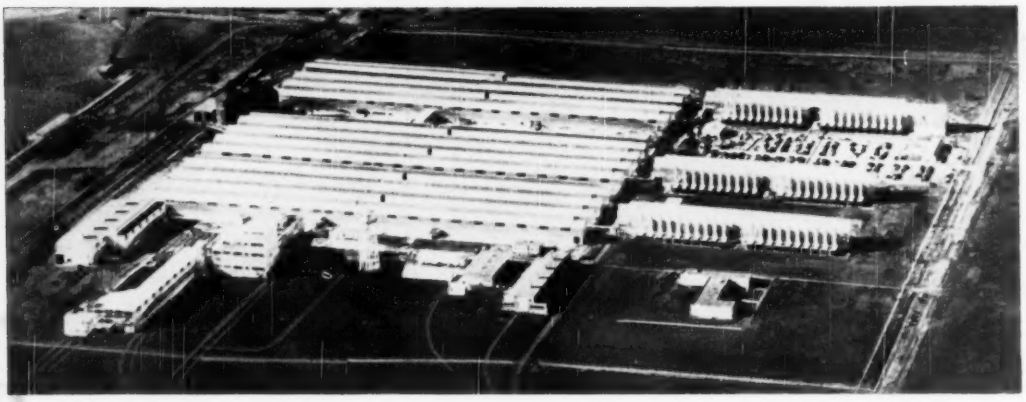
● A portable "alertness indicator" which signals lethargy in persons doing monotonous jobs has been developed for the Navy's Special Devices Center.

● Two GE generators have been in service in Massachusetts for more than 50 years. The only maintenance work done since the turn of the century came when the larger unit had its commutator refinished 10 years ago.

● A recent issue of the *Saturday Evening Post* carried a short note on the conversion of diesel air horns so they now sound very similar to the old steam locomotive whistles. Perhaps we'll hear less and less of the sad passing of the "dear old Iron Horse".

● The first session of the Oil Technological Institute in Madras Province at Anantapur in India is expected to be held late this year. The object of the Institute is to train apprentices leading to a diploma course in oil technology.

Alcoa's Point



Nordberg radial engines,—120 of them, provide a total of 192,000 hp., making this the largest internal combustion plant in the world.

A MAJOR factor in the competitive pricing of aluminum is the cost of obtaining or producing great quantities of dc. power. In addition, the supply must be firm since economic electrolytic ore reduction requires continuous operation for long periods. Except for short periods during the last war and in the early days of the industry, Alcoa has always used hydroelectric power. However, other sources are constantly being sought.

Upon examination of the other possible sources of power it becomes immediately apparent that the use of prime movers for electrical generation utilizing low cost natural gas offers interesting possibilities. To take maximum advantage of the low cost of gas it is expedient to locate near the source since even pipe line pumping is an added cost increment.

Other factors to consider in plant location are the transportation facilities and the existence of a suitable labor supply. Raw materials must be transported to the plant and the aluminum pigs and ingots shipped out. Following the policy of the Aluminum Company of America, a minimum of supervisory and technical personnel is moved to a new plant and the balance of the required labor is hired locally.

After consideration of all these factors, Alcoa decided to locate their new plant at Point Comfort, just outside of Port Lavaca, Texas. Construction of such a plant was not without precedent as Alcoa built a similar but smaller plant, under wartime censorship known as Project X, at Jones Mills, Arkansas.

A great deal of experience was gained in this earlier operation and the lessons learned had a great influence on the design of this new plant. Also, technological improvement in the ensuing years resulted in advanced design, not only with regard to the power plant but in respect to the pot lines.

HIGHLIGHTS

Horsepower, total	**192,000**
Generating cap., nominal kw.	**120,000**
Generating capacity for engine auxiliary drive, kva	**15,000**
Daily output, Approx. kw. hr.	**2,750,000**
Gas consumption, daily, cu. ft.	**30,000,000**
Approx. engine consumption loaded cu.ft. hr.	**13,000**
Aluminum production, lb. yr.	**114,000,000**

The outstanding feature of the new plant from our readers' point of view is the use of the Nordberg radial engine. Installation of 120 of these 2-cycle, 11-cyl., 14 by 16-in. engines, each with a rating of 1600 hp. at 360 rpm., makes this plant easily the largest internal combustion plant in the world—a distinction previously held by the plant at Jones Mills.

These radial engines are the result a joint development program by Nordberg and Alcoa engineers. They constitute a radical departure from heavy diesel or gas engine design. The first public showing of the engine took place in the Aluminum Ore Company plant in East St. Louis about two years ago upon the occasion of the 20th Annual Conference of the Oil & Gas Power Division of the ASME. The engine had been on test for a considerable period at that time and has been thoroughly tested in the ensuing period. So, although this is the first commercial application of the engine, it has served a severe apprenticeship.

Although the engine installations are of prime interest to our readers,

Comfort Works

it is felt that a description of the entire plant showing the integration of the power plant with other operations will be of interest.

General Plant Description

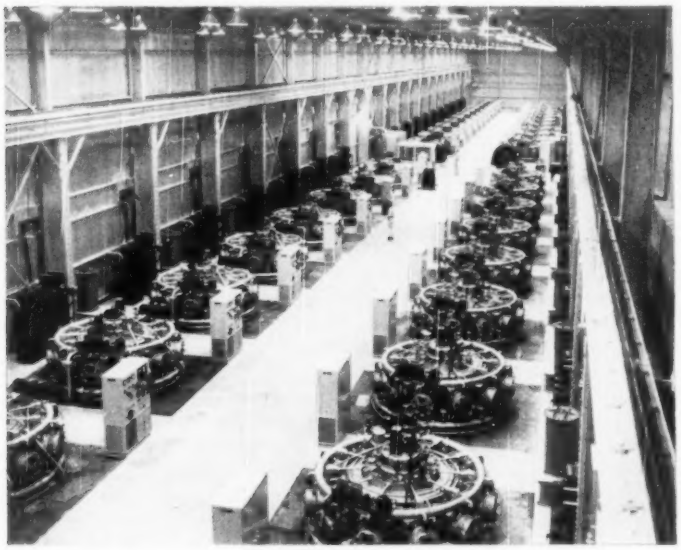
Grading and excavation for the Point Comfort Works began in August, 1948. The first aluminum ever made in Texas was poured at the works on February 11, 1950. Between these two dates, a modern aluminum reduction works was constructed on what had been a stretch of Texas ranch land.

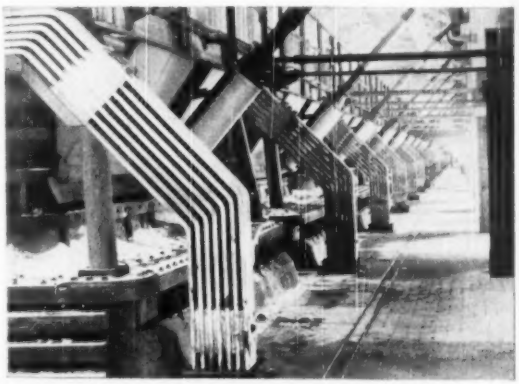
The Point Comfort Works is located on a tract of 3000 acres on Matagorda Bay near Port Lavaca and consists of 25 buildings with approximately 18½ acres of floor space. Included among these buildings are the pot rooms where aluminum is made; the engine rooms for the production of electric power necessary for making aluminum; a carbon plant; and various plant service facilities. Also included is a modern, air-conditioned office building containing about 15,000 sq. ft. of floor space.

The works has several miles of reinforced concrete pipe in its storm sewer system. Sanitary sewers lead to the works' own sewage disposal plant, where a considerable amount of aluminum is employed.

A concrete and steel dock was constructed at the works. A channel, complete with turning basin, connects the dock with the Pass Cavallo-Port Lavaca channel.

The Point Comfort and Northern Railroad, a subsidiary of Alcoa, owns fourteen miles of track between the plant site and Lolita, Texas, where a junction is made with the Missouri-Pacific Line. The railroad uses diesel engines.





One of three engine rooms (above) generating power for the pot lines, a section of which is shown at right. Note aluminum bus bars.

Electrolytic Reduction Process

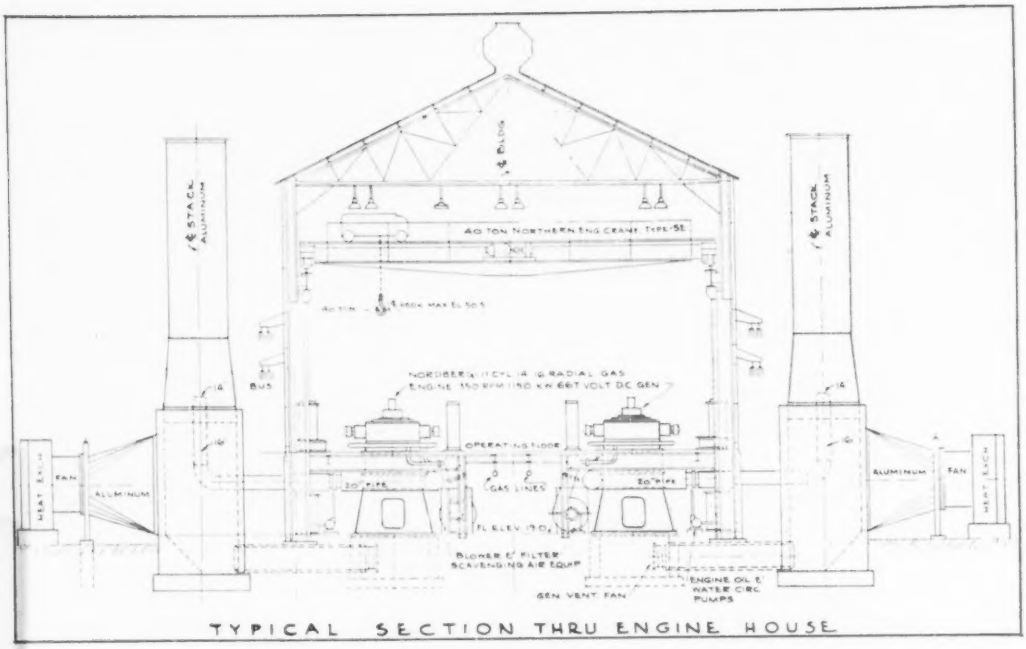
Aluminum is made by the electrolytic reduction of aluminum oxide. This reduction or "smelting" process is the heart of operations at the Point Comfort Works, which has a capacity to produce about 114,000,000 lb. of aluminum per year.

Aluminum Ore—One-twelfth of the earth's crust is aluminum. Although aluminum compounds can be found in any clay bank, it is not practical to use such sources of the metal for economical production.

At present, the ore used commercially is called bauxite, containing aluminum in the form of aluminum hydroxide. Because of impurities, bauxite occurs in various colors and textures. Deposits are known to exist throughout the world and much of the ore used in Alcoa's plants originates in Suriname, Dutch Guiana. In the United States, the principal source of ore is Arkansas.

Ore may be mined by the "open-pit" method or by a system of shafts and tunnels depending on the depth of the ore bed. The mining method for either type of deposit is much the same as that used for other materials.

Dirt and other loose impurities are removed from newly mined bauxite



TYPICAL SECTION THRU ENGINE HOUSE

by washing and screening. The ore is then crushed into pieces no larger than a walnut. After thoroughly drying in great kilns to remove excess moisture and save transportation costs, the ore is shipped to other plants to be refined. Bauxite, itself, cannot be used for making aluminum. Pure aluminum oxide is obtained from the ore, and it is the oxide which is actually reduced.

While there are a number of ways to refine bauxite, the Bayer process is generally used. In this process, the bauxite is first crushed to a powder and then mixed, in large pressure tanks, with a hot solution of caustic soda. The caustic soda dissolves the aluminum hydroxide but not the impurities. The solution is filtered and the impurities, collected in the form of red mud, are discarded.

The filtered solution is then pumped into great tanks. As it slowly cools, pure aluminum hydroxide settles out in the form of fine crystals. These crystals are washed with water to remove soda and are then ready for the next step in the process.

The crystals are fed into large revolving kilns and heated until white hot. The heat drives off all the chemically combined water in the form of steam. What is left is white, powdery aluminum oxide, more commonly called alumina. This is one of the raw materials shipped to the Point Comfort Works.

Cryolite—Another important material in the production of aluminum is cryolite, a double fluoride salt. Alumina is dissolved in the molten cryolite in the reduction cells so that the oxide may be reduced by the electric current. Cryolite is found in the natural state only in Greenland, but its synthetic equivalent is made and used.

Reduction Process — Aluminum is made in buildings known as "pot rooms". Several pot rooms normally comprise one "pot line", a reduction unit in which the electrolytic cells are arranged in series.

The electrolytic cell in which reduction takes place is a large, carbon-lined steel shell, commonly called a reduction pot. The pot is partially filled with cryolite, which is kept molten by means of the heat generated by the electric current. Current is introduced through a carbon anode which dips into the molten cryolite. The carbon lining of the pot acts as the second electrode or cell cathode.

There are various procedures in use today that employ a continuous, self-baking type anode, such as those used at Point Comfort. This anode consists of a large, single, rectangular casing supported by a superstructure mounted on the pot shell. A carbon paste is added to the casing from the top. The lower portion of the anode is baked by the high temperature of the molten cryolite in which it is immersed and serves to carry electric current into the cell. The baked carbon is consumed at the lower surface of the anode during electrolysis, and more paste is added at the top as required.

Carbon Paste—The preparation of carbon paste for use in the pots is an important function of a reduction works, since approximately $\frac{3}{4}$ lb. of carbon is consumed for every pound of aluminum produced. High-purity carbon is necessary for the anode because impurities in the carbon contaminate both the electrolyte and the reduced metal. The carbon plant facilities at Point Comfort keep the pot lines supplied with this essential material.

The process of making paste starts with petroleum coke, which is ground

to the required fineness in a mill. The coke dust is then blended and thoroughly mixed with hot pitch. The resulting paste-like material is delivered to the pots as needed.

At appropriate intervals during reduction, alumina is added to the molten cryolite. Electric current flowing through the molten solution decomposes the alumina into its component parts, aluminum and oxygen. The oxygen combines with the carbon anode and the aluminum, being heavier than the cryolite, remains at the bottom of the pot where it is liberated. At scheduled intervals molten aluminum is drawn off and poured into pig form.

Materials Handling

Now, with some idea of electrolytic process, the scope of the entire operation becomes apparent. To maintain continuous production and to handle the huge quantities of materials required, materials handling must be efficient.

Alumina, cryolite and the carbon paste must be supplied to the pots and after the smelting process, aluminum must be removed for pouring into ingots and pigs. Over-head cranes, with air conditioned cabs, are mounted so as to traverse the length of the pot rooms. The latter are all parallel. Transverse tracks provide for inter-pot room transportation.

Special containers for each material, fitting appropriately on the pots, are handled by the crane and rapidly feed the pots by gravity. When the pots are to be "tapped", a refractory-lined crucible is placed by the pot and the aluminum siphoned into it.

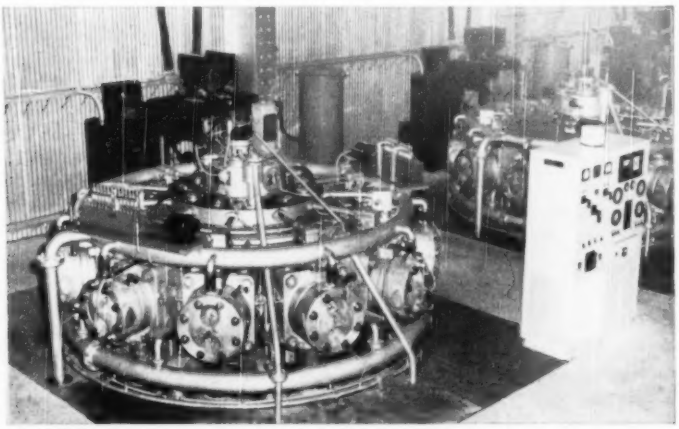
Filled crucibles are moved to the far end of the pot room where they are emptied into a special pouring crucible. This crucible is then moved by an electric rail car to the pouring room where casting of the pigs and ingots takes place.

From the time that raw materials arrive on the railroad siding until the aluminum returns for outloading, mechanical devices speedily and efficiently handle the material.

List of Principal Equipment

Engines	Nordberg Mfg. Company
Generators	40-General Electric Co. 40-Westinghouse Electric Corp. 40-Elliott Company
Motor-Generator Sets	Westinghouse Electric Corp.
Scavenging Blowers	Buffalo Forge Co.
Building Air Blowers	Joy Mfg. Company
Generator Cooling Air Blowers	Westinghouse Electric Corp., Sturtevant Division
Cooling System, Lube & Water	The Trane Company
Building Air Filters	Continental Air Filters Co.
Scavenging Air Filters	American Air Filter Co., Inc.
Circulating Pumps, Lube & Water	DeLaval Steam Turbine Co.
Lube Oil Purifier (continuous)	The Hilliard Corporation
Lube Oil Purifier (batch)	The DeLaval Separator Company
Mechanical Lubricators	Manzel Bros. Company
Ignition System	American Bosch Corporation
Spark Plugs	Champion Spark Plug Co.
Control Panels	Nelson Electric Mfg. Co.
Pyrometers	Illinois Testing Laboratories, Inc.
Cranes	Northern Engineering Works

Close-up of a single engine with its control panel and switch gear (on wall).



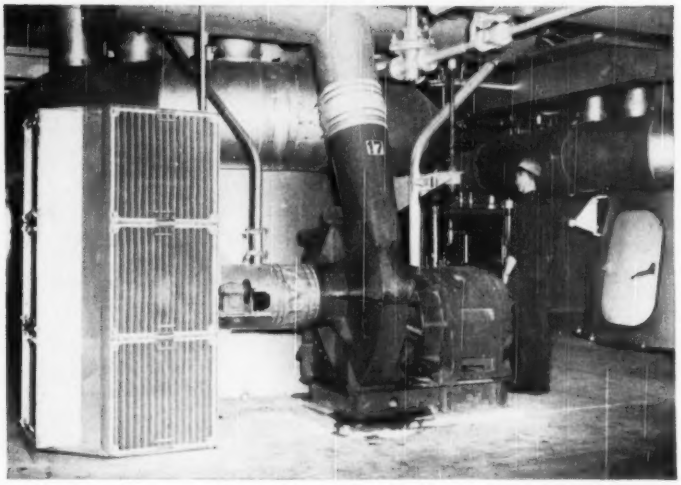
Power Plant

Radial engines are common in the gasoline engine field particularly for aircraft application and are not without precedence in the diesel field. However, such diesel engines have been designed primarily for aircraft or other transportational use with the idea of competing with similar gasoline engines. The idea of a heavy duty, low speed engine for stationary use is quite a departure from conventional design.

Upon reflection it becomes evident that the considerations of weight and space which lead to the development of the aircraft radial engines apply with equal force in the heavy engine field. Reduction in the required floor space and size and weight of foundations necessary to house and support such engines is a big cost factor. At today's construction costs, a reduction in the size of the plant structure can amount to substantial savings.

Radial disposition of the cylinders results in a crankcase structure of minimum size and weight and eliminates the usual frames. In addition, the base is simplified. Combined with

Generators are readily accessible through door in base for servicing.



Typical engine installation at lower level. Scavenging blower in center draws washed building air through filter at left.

this is the inherent balance of the reciprocating masses that serves to further reduce the necessity for heavy foundations. Then, with the engine superimposed horizontally on the base that houses the generator, maximum use is made of vertical space with a resultant saving in overall required floor area.

With each engine having a maximum diameter of 12 ft., 1 5/8 in., it was possible to distribute the 120 engines in three engine rooms each serving four pot rooms.

Even considering the comparative compactness of the engines, the 40 units, arranged in a double row, make an imposing sight.

A simple circular concrete slab is sufficient support for an engine-generator assembly. An Alcoa engineer stated that this was particularly fortunate because in other instances involving heavier weights and similar soil conditions, it had been necessary to sink piling to achieve sufficient flotation. Simple lag bolts hold the base firmly in place.

The base housing the generator, the scavenging blower and some accessory equipment is at the lower engine room level. The base extends upward through the engine room operating floor, placing the engine proper at an accessible level. Instrumentation is grouped in an attractive instrument panel near each engine.

The engine installation is exceptionally simple. In view of the availability and low cost of the gas, it was decided to use the lower compression, spark ignition version of this versatile engine. Under these conditions, the thermal efficiency of the engines is between 29 and 30 per cent. This is below what might be expected of a dual-fuel execution but can be tolerated, in fact is economical, due to the cost differential between liquid and gaseous fuel.

Each engine generator unit, with its auxiliaries, operates independently. The generators, with their armature shafts vertical, are directly coupled to the lower end of the engine crankshaft. Each generator produces 1000 kw. at 667 volts (pot line voltage) and 125 kva. (ac.) at 425 volts and 24 cycles. The ac. power is used for driving the engine auxiliaries. This eliminates the need for a common auxiliary power system and the possibility of a total station interruption. Along the wall behind each unit are the high speed switchgear, generator controls and starting equipment.

Scavenging air is supplied to the 2-cycle engines by separate scavenging blowers driven by 100-hp. electric motors. Air is supplied at a maximum rate of 7000 cfm. but is throttled at the blower suction at decreased load.

Each engine room has 40 building air washers. Each all-aluminum unit contains 30 washer cells and has a capacity of 35,000 cfm. Water is sprayed through each unit at a rate of 125 gpm. Air is drawn into the lower engine room through these filters by fans mounted in the building wall and serves the dual purpose of providing ventilation as well as scavenging and generator cooling air.

Building air is again filtered in panel type units before it enters the intake of the scavenging blowers. These efficient units insure that only uncontaminated air reaches the cylinders and this should be reflected in low wear rates.

A 7½-hp. motor turns an axial flow type generator cooling air fan to supply air at a rate of 12,000 cfm. After cooling the generators the air enters a cavity below the engine base and flows through a discharge pipe under the floor into the bottom of the concrete housing supporting the exhaust stacks.

Lube oil for the engine pressure system and piston cooling is stored in an aluminum sump tank. Both the oil pressure and circulating pump and the circulating water pump are driven by a common 15-hp. motor. The lube oil flow rate is approximately 120 gpm. Between 2 to 3 gpm. is bled off and passed through an earth type filter. Provisions for additional batch type purification are made by the in-

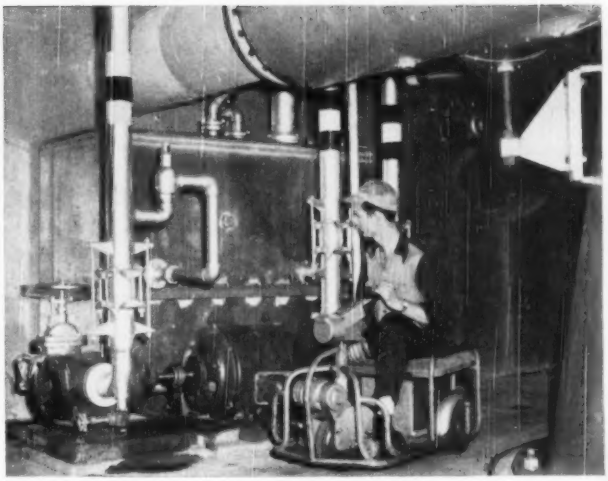
stallation of combination units comprising centrifuges and cellulose type filters.

Cylinders are lubricated by two mechanical lubricators per engine. These are driven by electric motors and supply metered amounts to the cylinder walls.

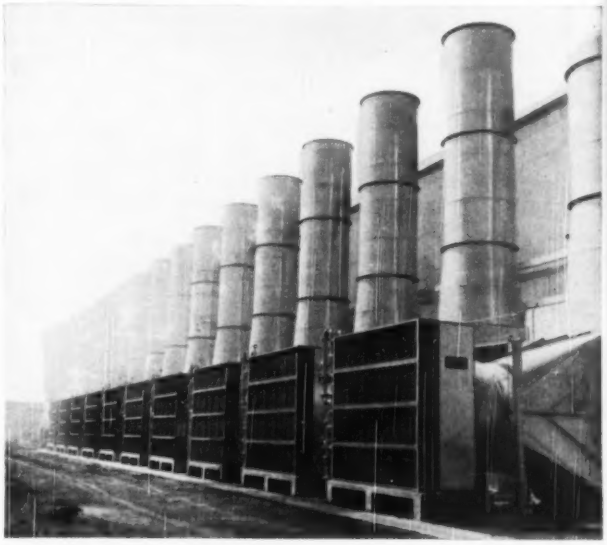
Combination lube oil and water coolers of the radiator type are installed for each engine. Alclad aluminum alloy 3S is used for both the tubing and fin stock and all-aluminum construction is used except for cast iron headers. Tubing is arranged in banks of three with the water tubes in front of the oil tubes. Each exchanger consists of four sections that can be cleaned or cut out of the system without interfering with the operation of the whole exchanger.

Cooling air is drawn through the exchangers by 84-in. fans, each having six adjustable blades and driven by a 2-speed 25-hp. motor. The air then enters the base of the exhaust stacks for discharge.

Two uses for the stacks have been mentioned and the third is, of course, for dissipation of the exhaust gases from the engine. Exhaust piping extends from the engine manifold through the building wall to the center of the associated stack where it takes an upward sweep. The 7½-ft. diameter stacks were fabricated by rivetting aluminum sheet right on the job. There are no silencers used; only some baffles in the stacks.



Lube oil sump tank and circulating pump. Water circulating pump is behind operator and driven from same motor. Exhause piping is above with blower for building air at right. Scooter facilitates inspections.



A row of exhaust stacks with water and lube oil coolers in foreground. Building air washers and filters are between stacks. Corner of one may be seen at right top of first cooler.

Instrumentation and Control

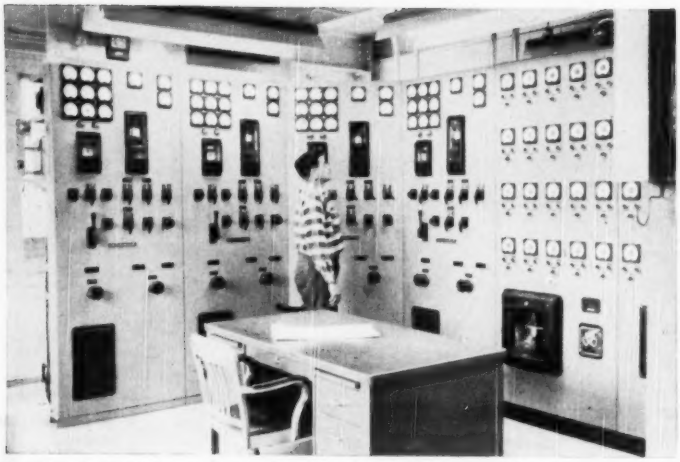
As previously mentioned, each of the engine-generator units has its own control panel. Included on the panels is the normal complement of gauges, a tachometer and a monitoring type of pyrometer. In addition, there are protective devices that will cause the engine to shut off automatically for such reasons as low oil pressure, high water temperature, high exhaust temperature, overspeed, high generator temperature, or loss of auxiliary power.

The pyrometers are of interest as they are one of the latest Alnor developments originally designed for this installation. In order to appreciate the need for this equipment it is necessary to know something of the plant operating methods.

The power plants were designed to function with a minimum of attendance. Automatic features are then understandably important.

Manual switching of the pyrometer indicator from cylinder to cylinder would become quite a chore with forty engines to attend. With these new units, a motor continually drives the switching mechanism. Meter readings can be correlated with a particular cylinder by reference to a synchronized pointer. Dimensioning is such that readings can be taken at a distance of up to 20 ft. The mechanism also contains a stop button for closer reading and provision for an automatic excess temperature cut-off.

In addition to unit control panels, each engine room has a master con-



A portion of one of the master control rooms. Output voltages may be checked and altered if necessary.

trol room fitted with recording and indicating equipment registering the operation of each of the 40 engines and generators. No unit can be shut off from this location but voltage adjustments can be made and the general operation observed.

Gas Supply System

The Lavaca Pipe Line Company, a subsidiary of Alcoa, was organized for the purpose of operating the pipe line necessary for gathering and distributing the gas to be used in the works.

Gas is received from both on-shore and off-shore wells. One pipe line, built in the fall of 1949, runs between the Point Comfort Works and the Francitas Gas Company's recycling plant near Francitas, Texas. There are approximately 11 miles of 10-in. pipe and 5½ miles of 8-in. pipe in this line.

Another line, consisting of 7½ miles of 8-in. pipe, ties into the off-shore line in Matagorda Bay.

The main underwater line, in Lavaca and Matagorda Bays, consists of approximately 14 miles of 8-in. pipe, about 12½ miles of it under water. In addition, approximately 9 miles of 4-in. and 6-in. pipe are used for the off-shore gathering lines. The average depth of water in the off-shore gasfield is about 14 ft.

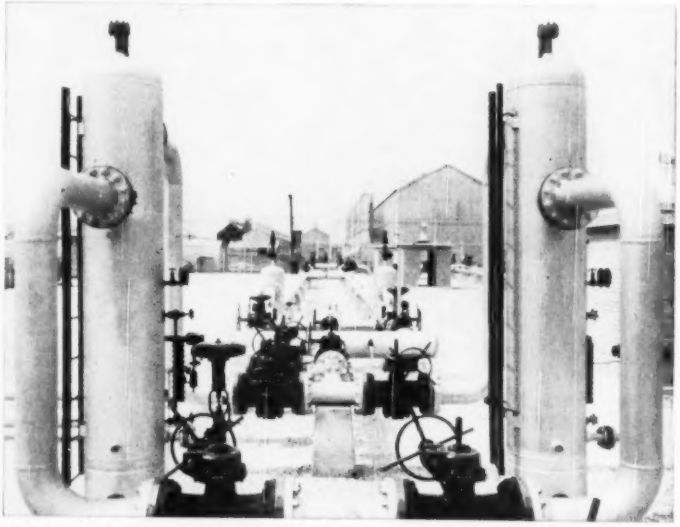
A control and metering station, built well above the water level, is located on a platform constructed of creosoted piling. The gathering system, which includes lines from eleven wells, leads to a 12-in. header on the platform; the header, in turn, discharges into the 8-in. transmission line. Meter runs on the platform are in parallel, and the entire station layout is compact.

Magnesium anodes for cathodic protection were installed at the shore end of the line, at the metering platform at several intermediate points on the line.

One experimental gathering line consists of about 4000 ft. of 4-in. aluminum pipe instead of the steel pipe used for the rest of the system. One half of this aluminum line was left bare and the other half was wrapped in the usual way.

On-shore and off-shore lines terminate at the pressure reducing station located on the reduction works site to supply the 30,000,000 cu. ft. daily requirement for gas at the works.

Natural gas is delivered at a pressure of from 400 to 500 psi. This pressure is reduced in two stages to 60 psi. The gas is dry and free from sulfur. It has a heating value of about 1000 Btu. per cu. ft. Two 8-in. gas lines connect each of the three power houses with the pressure reducing station. A regulator at each engine further reduces the intake pressure, and in actual operation, gas enters the engine at a pressure of about 6 lbs. A separate line, metered and pressure controlled, supplies gas for general plant use.



Gas arrives at "tee" in center foreground and branches to separators. Pressure reduction follows, more separation and then final reduction stage.

Auxiliary Power Equipment

The 667-volt dc. power delivered by the engine-driven generators is not satisfactory for other plant needs. Alternating current and also dc. current at different voltages are required and these are supplied by four motor generator sets. Power from the buses

is used in a motor to drive a 4000-volt, 60-cycle alternator for general plant power and a 250 volt, dc. generator for powering the electrical equipment serving the pot lines.

There is an interesting application of a Woodward hydraulic governor in connection with these sets. Speed control of dc. motors is always a problem and in this case is necessary to control the cyclic rate of the alternator. A synchronous motor, taking power from the alternator, is used to drive the governor and since its speed will vary in direct proportion to the cyclic variation of the alternator, it senses changes in the driving motor speed. The power piston of the governor is connected by linkage to a rheostat in the field of the dc. motor and thus alters the resistance appropriately to maintain a constant speed.

Storage batteries provide a 125-volt source of power for general plant use such as circuit breaker operation, etc. These are located in a well ventilated room in the lower level of each engine house.

Maintenance

Actual maintenance procedures cannot be definitely established on such a new plant but planning is well advanced on the basis of experience during the testing period. The use of clean, dry, and sulfur free gas, carefully filtered air and rugged engine design indicate that maintenance difficulties will be minimized.

One of the reasons behind the choice of such comparatively small engine units was the flexibility of operation that they offered. Previous experience at Jones Mills indicated the advisability of multiple units of approximately this size so that a few could be shut down for periodic servicing or even go out of commission without interfering with aluminum production. Bear in mind that continuity of operation is extremely important in making aluminum.

Engines were placed in operation as soon as installed so as to vary the number of operating hours on each. Current plans also include the breaking of step just as soon as possible to permit a staggered scheduling of maintenance.

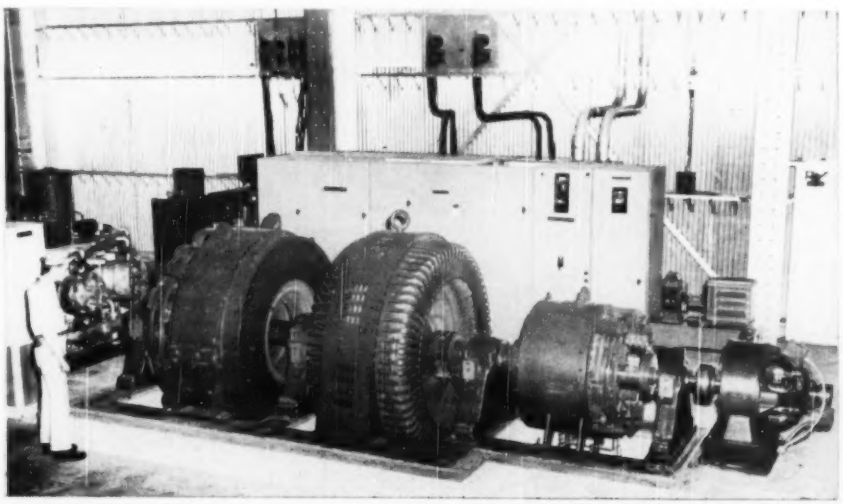
Automatic controls have been used wherever possible to eliminate the need for constant attendance. This measure of safety plus the monitoring in the master control room makes this practical and also permits logging of instrument reading to be reduced to once per shift. The required personnel is also reduced as the operators are free to concentrate their efforts where most needed. The distance factor in the huge engine rooms is overcome by the use of small electric scooters for transportation.

Formulation of maintenance policies and procedures as well as general power plant supervision will be the responsibility of Mr. Howard Keefer. Already, he has compiled considerable experience with these new engines by intimate association in the testing and development stage and through supervision of the installation.

Use of Aluminum in the Plant

Frequent mention has been made of aluminum construction in describing the plant. This has by no means exhausted the applications. Although Alcoa would naturally lean to such application it would be impractical if the application did not offer functional or economic advantages. As an example, any additional cost of the aluminum corrugated roofing and siding used for covering the production buildings is offset by a reduction in construction and handling cost engendered by its light weight.

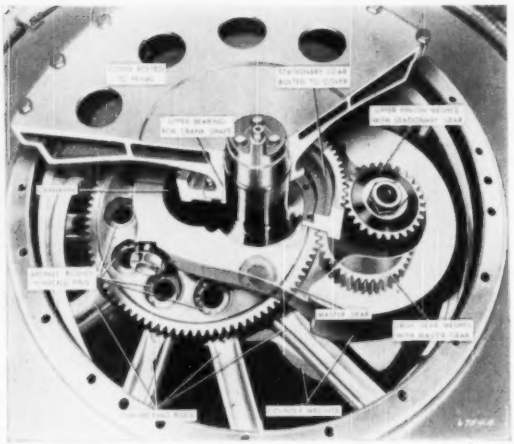
Aluminum is used in the office buildings for doors, windows, hardware, lighting fixtures, trim and decorative effects. Outside installations include the fence, lamp poles and electrical conductors. Approximately 5½ million pounds of aluminum bus conductor alone was used. There are three 5000-ft. circuits, each including an engine room and a pot line, and the main bus consists of 22 bars, each with a cross section of ¾ in. by 10 in.



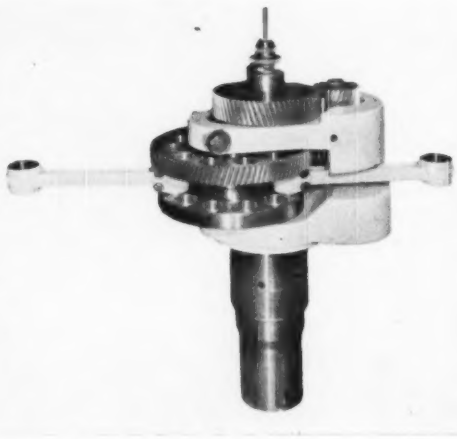
At left, dc. motor drives alternator, a dc. motor and an exciter. Hydraulic governor speed control is at right of panels.

Design Features of the

Nordberg Radial Engine



Top view of the crankcase showing various details of assembly of the new engine.



Crankshaft assembly showing the stationary gear, pinion, and master bearing gear.

by Donald I. Bohn and Emil Grieshaber

This paper describes design features and inherent characteristics of the Nordberg Radial Engine, a new impulse type ignition system and different applications. The authors are, respectively, Chief Electrical Engineer, Aluminum Company of America, and Chief Engineer, Nordberg Manufacturing Company. This paper was first presented at the meeting of the Oil and Gas Power Division of the ASME held in Baltimore June 12-16, 1950.

THE NORDBERG Radial engine is built with eleven cylinders of 14 in. bore and 16 in. stroke and at 400 rpm. develops 1300 hp. or 1250 kw. It is of the two cycle type with port scavenging and port exhaust, the piston undercovering the ports in the cylinder walls thereby eliminating intake and exhaust valves. It is built as a spark fired gas engine, as a diesel unit and as a Duafuel engine.

The motor driven scavenging blower, lube oil and water pumps can be connected directly to the leads of the generator, thus making a self-contained automatic unit, with a net capacity of 1150 kw. or power may be supplied to the auxiliaries from a station busbar and utilizing the gross output of the engine for pump or compressor drives.

The basic advantages of a radial engine design result in a simple compact and sturdy arrangement, light weight, minimum foundations and small floor space. This engine with its welded base is a little over 12 ft. wide, 9 ft. 4 in. high, weighs approximately 85,000 lbs. and can be shipped by rail as an assembled unit.

Since the cylinders fire one after the other in clockwise rotation the piston loads are transmitted to the crankpin at an even sequence, consequently the torque variations are small in magnitude. Opposite pistons counteract the peak cylinder pressures and therefore the resulting loads on the crankpin and the two main bearings are greatly reduced and of small variation. This effect together with a small number of bearings reduces friction and improves the mechanical efficiency of the engine.

The radial arrangement of the cylinders makes possible a perfect static and dynamic balance of the engine. The first order inertia force to be balanced equals the sum of the inertia force of the rotating and $\frac{1}{2}$ of that of the reciprocating masses of all cylinders. This force acting in the direction of the crankthrow can be completely balanced by counter-

weights as there are no free forces or moments transmitted to the foundation of the engine. All the higher order inertia forces are inherently completely balanced without any counterweights except 11th, 22nd, 33rd etc. orders which are of negligible magnitudes, thus the engine is free of vibrations and requires only a light foundation.

The problem of torsional vibrations is greatly simplified since the stiff single throw crankshaft results in a high natural frequency. Most of the orders that are so familiar to designers of in-line engines are eliminated in this engine due to the radial attachment of the moving parts of the cylinders to a single crank throw. The resulting exciting torque of all cylinders is zero for all orders except for the 11th, 22nd, 33rd etc. order critical speeds. Of these torques, only the 11th order is of any appreciable magnitude and it can readily be located above normal operating speed on short shaft installations. Smooth operation, free of torsional vibrations, is achieved throughout the entire range. In applications requiring a long shaft where several modes of torsional vibrations are possible, the number of critical speeds is reduced to a minimum; this greatly simplifies the elimination of torsional vibrations within a wide operating range.

The load on the crankpin bearing can be determined by combining graphically the resultant forces along the connecting rod axis due to cylinder pressures and the centrifugal force of the master bearing and rotating parts of the connecting rod. The main bearing load is merely the graphical sum of the cylinder pressures since the centrifical forces are completely balanced by the counterweights. The load diagrams are illustrated, the force S indicating the direction and magnitude of the load for a given crank angle with respect to cylinder No. 1.

In all radial engines the rotation of the crankpin bearing upon which the connecting rods are mounted must be prevented in order to obtain constrained motion of the connecting rod crank end. This is usually accomplished by use of a master connecting rod. A newly designed patented method is used in the Nordberg Radial engine whereby the master crankpin bearing is prevented from rotating by the use of a planetary gear train which connects the master bearing gear to the stationary crankcase cover. This gear train consists of four gears. The stationary gear 1 is fastened to the underside of the crankcase cover and is connected through a unit consisting of the small pinion 2, drive shaft and larger drive gear 3 to the gear teeth of the master bearing 4. The connecting gear unit is mounted in the upper counterweight of the crankshaft opposite the crank throw.

It can readily be seen from the schematic diagram that if the gear ratios N_1 to N_2 and N_3 to N_4 are equal as is the case in this gear train, the gears 1 and 4 must have the same angular velocity because pinion 2 and drive gear 3 revolve as a unit. Since gear 1 is stationary, gear 4 cannot revolve with respect to the stationary part of the engine. The position of the crankpin on which the master bearing is mounted merely takes care of the larger center to center distance of gears 3 and 4 as compared with the gears 1 and 2. Thus the master bearing revolves at —N rpm. with respect to the crank, if the crank revolves at N rpm. with respect to the stationary part of the engine. In other words, the resultant angular velocity of the master bearing with respect to the stationary part of the engine is zero and the master bearing is merely translated by the rotation of the crank.

This type of motion of the master bearing has great practical advantages. Since the center of the master bearing is moving along a circular path, every point of the bearing moves along circles of equal diameters. Therefore, the knuckle pins which correspond to crankpins in the connecting-rod-crank-mechanism, describe identical circles thus making the moving parts of every cylinder kinematically identical. Consequently, interchangeable parts can be used in all cylinders and the timing of the engine is greatly simplified and identical for all cylinders.

The forces acting on the crank mechanism of the radial engine are shown in the illustration. Starting with the actual indicator card and the inertial forces, the net reciprocating force P acting on the piston can be determined. Since the design eliminates the master rod and articulated rods, and since all moving parts of each cylinder follow the same path, the displacement, velocity, acceleration and thus the inertia forces of each piston are identical and the figure applies to all cylinders.

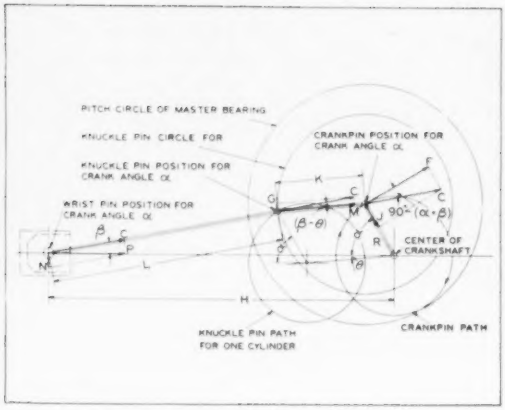
The connecting rod force can be transferred to the master bearing knuckle pin and the crankpin and resolved mathematically into several different forces. Using equations thus established, the torque on the cylinder wall, master bearing and crankpin or engine crankshaft can be determined. Following through with these calculations, it can be shown that the crankshaft torque is equal to the cylinder wall torque minus the master bearing torque.

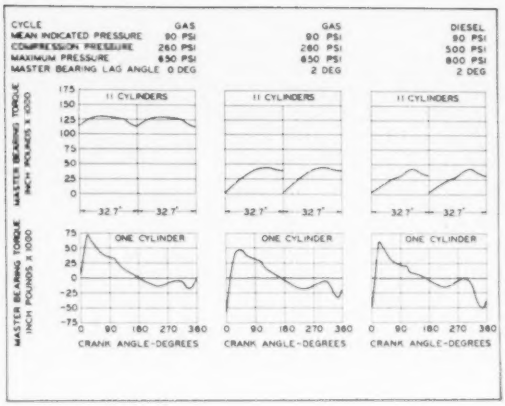
From the discussion of the gear train, it is seen that the torque on the stationary gear is equal in magnitude and direction to that of the master bearing gear. From these torques the tooth loads on the different gears can be determined. Due to their smaller pitch diameters the loading of the pinion and stationary gear will be greater than that of the drive gear and master bearing gear.

As is evident from the illustration of the master bearing torque curves, the tooth loading changes noticeably with a change in master bearing lag angle. As an example, for the gas cycle with a lag angle of zero degrees the tooth loading at full load equals a maximum of 11,500 lbs. whereas with two degrees lag angle the load is reduced to 4000 lbs.

The vertical thrust loading on the bearings supporting the pinion, drive gear and connecting shaft is reduced to a minimum by the proper choice of the helix angle and the hand of the gears. *For those of our readers who are interested in the various force equations mentioned in the preceding five paragraphs, these equations are presented elsewhere in this article. —Ed.*

The Nordberg Radial engine when


PITCH CIRCLE OF MASTER BEARING
KNUCKLE PIN CIRCLE FOR
KNUCKLE PIN POSITION FOR CRANK ANGLE α
CRANKPIN POSITION FOR CRANK ANGLE α
WRIST PIN POSITION FOR CRANK ANGLE α
CENTER OF CRANKSHAFT
KNUCKLE PIN PATH FOR ONE CYLINDER
CRANKPIN PATH


CYCLE
MEAN INDICATED PRESSURE
COMPRESSION PRESSURE
MAXIMUM PRESSURE
MASTER BEARING LAG ANGLE
GAS 90 PSI 260 PSI 650 PSI 0 DEG
GAS 90 PSI 260 PSI 650 PSI 2 DEG
DIESEL 90 PSI 500 PSI 800 PSI 2 DEG
MASTER BEARING TORQUE INCH POUNDS X 1000
11 CYLINDERS
ONE CYLINDER
CRANK ANGLE-DEGREES

Design Equations

The net reciprocating force P at any crank angle α can be resolved into the following:

$$C = P / \cos \beta \quad (1)$$

$$N = \tan \beta \quad (2)$$

where C = Connecting rod force — lbs.

N = Force normal to cylinder wall — lbs.

β = Connecting rod angle — degrees.

Transferring the connecting rod force C to the master bearing knuckle pin and the crankpin, it can be resolved into the following:

$$G = C [\sin (\beta - \theta)] \quad (3)$$

$$M = C [\cos (\beta - \theta)] \quad (4)$$

$$F = C \{\cos [90^\circ - (\alpha + \beta)]\} = C [\sin (\alpha + \beta)] \quad (5)$$

$$J = C \{\sin [90^\circ - (\alpha + \beta)]\} = C \cos (\alpha + \beta) \quad (6)$$

where G = Tangential force on master bearing — lbs.

θ = Master bearing lag angle — Degrees

M = Radial force on master bearing — lbs.

F = Tangential force on crankpin — lbs.

J = Radial force on crankpin — lbs.

Torque on Crank Chain

From the fundamental force equations (1 to 4), we can determine the corresponding torque on the cylinder wall, master bearing and crankpin or engine crankshaft.

Cylinder Wall Torque

$$= N \times H$$
$$= P \tan \beta \, H$$
$$= P \tan \beta \, [L \cos \beta + R \cos \alpha + K \cos \theta]$$
$$= P [L \sin \beta + R \tan \beta \cos \alpha + K \tan \beta \cos \theta] \quad (7)$$

where H = Distances from L wrist pin to L crankshaft, in.

$H = L \cos \beta + R \cos \alpha + K \cos \theta$

L = Connecting rod center length, in.

R = Crank radius, in.

K = Knuckle pin radius, in.

Master Bearing Torque

$$= G \times K$$
$$= C [\sin (\beta - \theta)] K \text{ from Eq. 3}$$
$$= C [\sin \beta \cos \theta - \cos \beta \sin \theta] K$$
$$= \frac{P}{\cos \beta} [(\sin \beta \cos \theta - \cos \beta \sin \theta)] K \text{ from Eq. 1}$$
$$= PK [\tan \beta \cos \theta - \sin \theta] \quad (8)$$

Crankshaft Torque

$$= F \times R$$
$$= C [\sin (\alpha + \beta)] R \text{ from Eq. 5}$$
$$= \frac{P}{\cos \beta} [\sin \alpha \cos \beta + \sin \beta \cos \alpha] R$$
$$= PR [\sin \alpha + \tan \beta \cos \alpha] \quad (9)$$

The relationship between these torques can be shown as follows:

Since $R \sin \alpha = L \sin \beta + K \sin \theta$

equation 9 becomes: $FR = P [L \sin \beta + K \sin \theta + R \tan \beta \cos \alpha]$

and as $G = P [\tan \beta \cos \theta - \sin \theta]$ from Eq. 8

or $\sin \theta = \tan \beta \cos \theta - \frac{G}{P}$

$F R = P [L \sin \beta + R \tan \beta \cos \alpha + K \tan \beta \cos \theta] - GK$

or $F R = N H - G K \quad (10)$

which states that the crankshaft torque is equal to the cylinder wall torque minus master bearing torque.

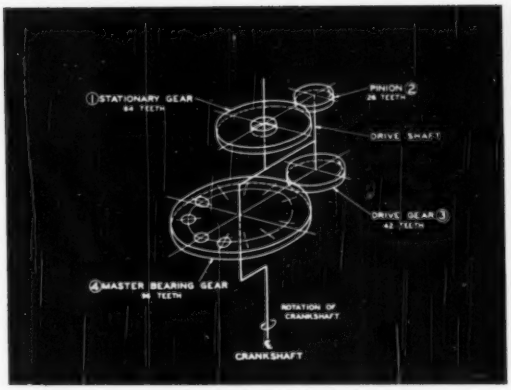
It is obvious from the discussion of the gear train, that the torque on the stationary gear is of identical magnitude and direction to that of the master bearing gear which is shown for various operating conditions.

From these torques the tooth loads on the different gears can be determined. Due to their smaller pitch diameters the loading of the pinion and stationary gear will be greater than that of drive gear and master bearing gear and may be found from the following relationship:

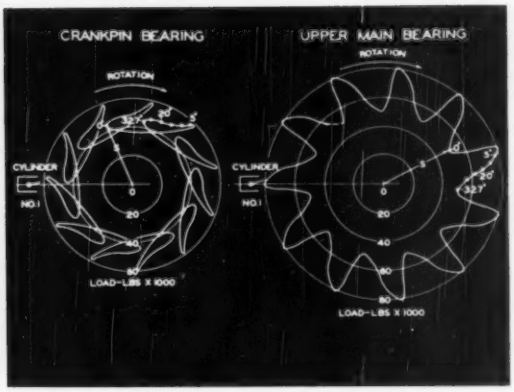
$$G_s = 2 G K / D_s \quad (11)$$

where G_s = Pinion and stationary gear tooth load, lbs.

D_s = Pitch diameter of stationary gear, inches.



Schematic gear train diagram showing the relationship between the gears.



Bearing load diagram. The force S indicates the direction and magnitude of the load for a given crank angle.

arranged for gas burning, operates on spark ignition about 260 psig. compression and 650 psi. firing pressure. In each cylinder is a gas inlet valve, located above the scavenging ports. These valves are actuated by rocker arms and push rods from a cam located on the upper portion of the crankshaft. They introduce the gas at low pressure in the cylinders into the path of the incoming scavenging air to assure thorough mixing. Two spark plugs are in a vertical plane and fire at different crank angles before top dead center. The amount of gas delivered to the cylinders is varied in accordance with the load on the engine by means of a valve inserted in the gas header and connected to the governor. The volume of scavenging air is also controlled proportionate to the load by throttling on the blower suction.

The engine is equipped with a new type of ignition system designed to operate for indefinitely long periods of time without attention or maintenance, and to also insure a very low rate of spark plug electrode erosion.

Ignition energy is supplied by a special impulse generator whose output, at the plugs, consists of accurately timed, unidirectional impulses similar to an individual half -cycle of a conventional A-C wave. This generator involves no cams, breaker points, brushes, collector rings, or rotor windings.

The general construction involves a four-element rotor, each element of which consists of a permanent-magnet assembly, magnetically distinct from the other elements, and equally spaced. The stator consists of laminated punchings with four windings. The generator operates at $2\frac{3}{4}$ times engine speed, or 990 rpm., so that the generator rotor makes $\frac{1}{4}$ revolution for each 1 11 revolution of the engine. Although the permanent magnet rotor elements are equally spaced, the stator coils are displaced in pairs by 20 deg., as shown. This is done to provide a firing differential of about $7\frac{1}{4}$ engine degrees between the two plugs in each cylinder. The lower plug fires at 15 deg. BTDC, and the upper plug fires later at approximately 8 deg. BTDC. Experiments indicate that improved smoothness of operation and reduced pressure peaks result from this differential firing.

Normally, either a single stator coil or a pair connected in parallel is employed to supply one ignition circuit of one set of 11 plugs. A single stator coil provides ample energy for this purpose at half speed or above, and when ignition must be supplied at low starting speed, such as a quarter of normal, a switch may be employed to connect the two opposite coils in series for the starting period.

The transformer differs from an ordinary spark coil in that the iron circuit is complete as in a conventional transformer. For this engine, it is designed to provide a maximum peak voltage of 25 KV., which is ample for the compression used.

The high-tension distributor, operating at engine speed, is conventional except that it is made for two circuit operation with connections to each of the 22 spark plugs.

An oscillogram of the output of one generator coil, with and without the selenium rectifier is shown. With the selenium rectifier in circuit, the two small positive impulses are eliminated and a single unidirectional impulse results.

A special 500,000 ohm resistor is connected in series with each spark plug and located at each plug. This resistor is effective in preventing the harmful effects and rapid spark plug erosion normally resulting from the capacitative energy stored in long high-tension leads. In addition, the fact that all impulses to each plug are unidirectional is conducive to low spark plug electrode erosion. The polarity relationship of the various elements is so arranged that the center spark plug electrode is negative, thus concentrating the erosion on the multiple and cool grounded electrodes.

These engines when operating on natural gas with a high heat value of 1003 and low heat value of 910 Btu/cu.ft. showed a fuel consumption of 11.4 cu.ft. per gross kw. hour or 12.42 cu.ft. per net kw. corresponding to 7970 Btu. per net bhp. hour.

When the engine burns oil it operates on the diesel cycle with normal compression and mechanical injection of the fuel. It is started by compressed air admitted through a rotary

distributor to a starting valve in each cylinder head. The fuel pumps, one for each cylinder, are located in a horizontal plane above the crankcase cover and are actuated by a cam on the crankshaft. The fuel injection nozzles are centrally located in the cylinder heads and all fuel lines are the same length. The load and speed of the engine are controlled by a hydraulic governor acting directly on the fuel pumps.

As a Duafuel engine it operates with pilot oil injection. The fuel pump has a double helix plunger and variable retraction valve. The flat helix measures the pilot oil for gas operation and the steep helix is brought into action when operating on fuel oil. The displacer piston of the discharge valve is so arranged that the retraction volume varies from zero to a maximum in proportion to the amount of fuel discharged per pump stroke. This results in higher injection pressures for very small quantities and a more even pressure rise over the whole capacity range of the fuel pump. Shifting from one fuel to the other can be done without interrupting the operation of the engine.

The cross section of a spark ignition gas burning engine driving a generator is also shown. The engine is mounted on a welded base which also carries the generator and a steady bearing and supports the scavenging and exhaust headers. The whole unit is self-contained, can be quickly erected in the field and requires only a small and simple foundation.

Another application is shown where a radial engine drives a centrifugal pump or a compressor. The engine rests on a short sub-base which also carries the step-up gear. The high speed shaft extends downwards to the driven unit which is below and separated from the prime mover by a tight floor.

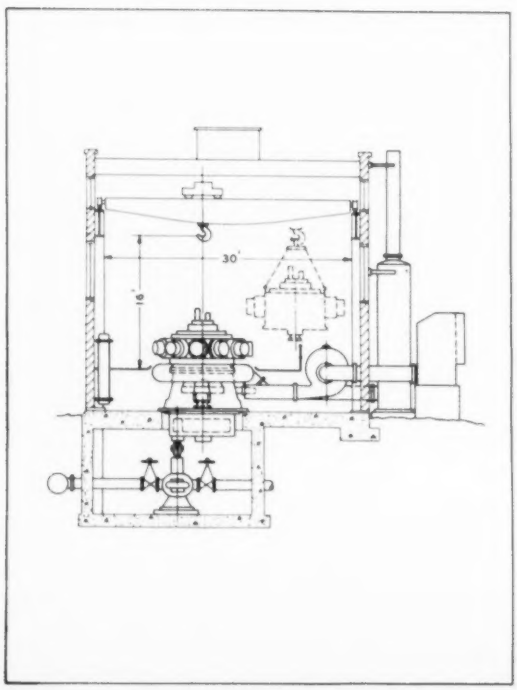
The cylinders are lubricated by force feed: the bearings, gears and other moving parts by a continuous pressure system. The lube oil enters through the main bearing into the crankshaft and by means of passages is distributed to moving parts throughout the engine. The oil used for cooling the pistons enters and leaves the pistons through rifle drills in the connecting rods returning to the lower part of the crankcase. From there it drains together with the balance of the returned lube oil to a sump tank to be strained, cooled and recirculated.

The unusual design of the crankshaft can be seen from the engine cross-section, the photograph of the crankshaft assembly with two connecting rods, and the top view of the crankcase. The crankshaft is of two piece construction and made of high tensile cast iron. It has two bearings of the babbitted bronze shell type, the lower one being in the central hub of the crankcase, the upper one in the crankcase cover. The lower section of the crankshaft comprises the short, sturdy shaft, lower counterweight and crankpin. The underside of the counterweight has a polished thrust face which rides on the eight tilting pads of the thrust bearing which supports the weight of the shaft assembly, generator shaft and rotor.

The upper section of the shaft consists of the upper counterweight and the upper shaft journal. The drive gear and pinion are attached to the upper counterweight. With the master gear in position on the crankpin, the upper section is then attached to the lower section by doweling and clamping, thus making a rigid assembly.

The pistons are aluminum-alloy forgings and so are the ring carriers, which are shrunk over the upper portion of the pistons. They carry the piston rings and also provide passages for the piston cooling oil. The wrist pins are of the floating type. The connecting rods are one piece drop forgings. The knuckle pins are tightly clamped into the crankend eyes of the rods and are carried in two bearings located in the two flanges of the master gear. All bearings are of the one piece bronze bushing type, no split shells being used.

Many elements of this engine are of conventional design, others were modified to suit the radical arrangement. No particular effort was made to produce a light weight engine. The moderate weight in comparison to other engine types of like duty is inherent to the radial design.



Radial engine arranged for pump drive.

Cooling the Point Comfort Engines

*by Edward F. Higgins**

EFFICIENT performance of the closed circuit cooling system at Alcoa's giant Point Comfort works holds special interest for the diesel power user because of increasing shortages of water suitable for industrial power uses.

Design of an engine cooling system capable of dissipating more than 300 million Btu's per hour was complicated by impurities present in the only water available at Port Lavaca, Tex.

Cost of water treatment and pumping facilities for make-up water made discharge of jacket water to the Gulf or the use of cooling towers or evaporative condensers impractical.

The dry type of fluid cooler offered both water economy and efficient cooling performance. In addition, both jacket water and lube oil could be cooled in the same unit.

The accepted design for the Point Comfort all-aluminum fluid coolers is essentially identical with the design of the standard Trane line of 22 fluid cooler sizes. Several modifications were made to fit local conditions.

One cooling unit serves each of the 120 Nordberg radial engines in Point Comfort's power plant. Located in banks of 40 outside of each power plant building, the lines of fluid coolers and exhaust stacks constitute the dominant architectural feature of the works.

Each fluid cooler consists of cooling coils, fan, fan motor and casing. Each unit stands 11½ ft. high, 13 ft. long, and 9 ft. deep.

Each has a six-bladed "sucker" propeller fan 84 in. in diameter, driven directly by a 25 hp., two-speed motor, running at 600/300 rpm. The blades of each propeller fan may be adjusted to three different pitches to vary the flow of cooling air according to seasonal requirements, and to permit economical operation at the lower speed in cooler weather. At 600 rpm. each fan draws 78,000 cfm. of standard air. The entire system, in full operation, can draw a total of 9,360,000 cu. ft. of air per minute, dissipating 317,700,000 Btu. per hour.

Because air leaves the water coils at 130 deg. F. too warm a temperature for efficient cooling of the fan motor, a separate motor air intake is provided. A door to the plenum chamber is provided for easy inspection and lubrication of the motor and for adjustment of the fan propellers.

Each unit contains four fin-and-tube cooling coils with 125 square ft. of frontal area. Each coil has two cores, one for cooling engine jacket water, the other for lube oil.

The oil cores and water cores were put in the same casing to simplify the job, saving both materials and fabrication labor. Air entering the coolers strikes the oil cores, with a comparatively low temperature rise, first. It then passes through the water courses, into the plenum chamber, through the draw-in fan, and out to the exhaust stack. These stacks also carry off exhaust gases and generator cooling air.

Heat transfer in the oil sections of the fin and tube coils is improved by use of "Turbulators", spiral strips of aluminum that increase the "washing" of the lube oil on the internal wall of the tube. Turbulators were not necessary in the water tubes because of the higher circulation rates.

The four coils in each unit are separated by ⅛ in. aluminum spacers, which facilitate removal of the coils for replacement or maintenance. Drains in the bottom of two headers and air vents in the top two headers of each unit permit easy filling or draining of the coils for repairs.

Important performance specifications for the coolers follow:

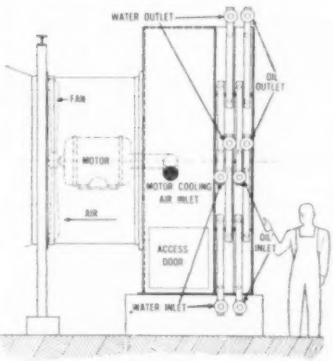
Water

Heat dissipation, 2,000,000 Btu/hr.
Circulation, 400 gpm.
Temperature drop in unit, 155 to 145 deg.

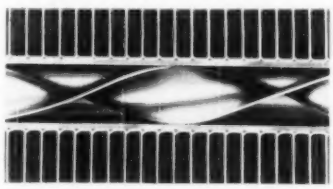
Oil

Heat dissipation, 647,500 Btu/hr.
Circulation, 150 gpm.
Temperature drop in unit, 145 to 125 deg.
Specific gravity, 0.9
Specific heat, 0.48
Viscosity, 660 SSU @ 100 deg.
Design ambient temperature, 100 deg. F

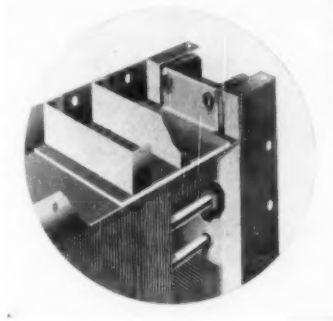
(*Concluded on page 39*)



General arrangement of the heat exchangers and fan for cooling each engine.



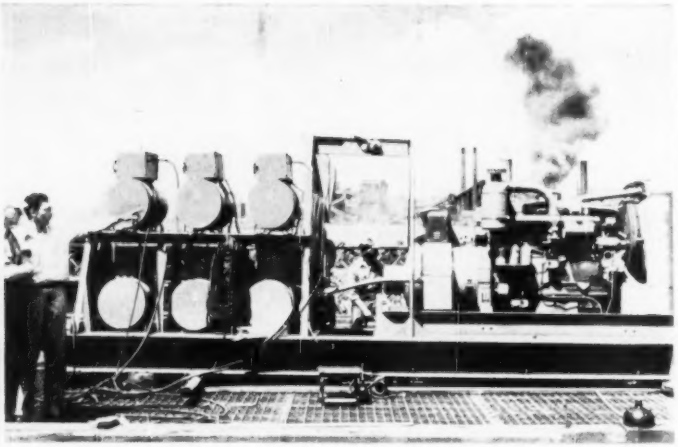
Spiral aluminum strips in the lube oil tubes insure maximum oil-tube contact.



Cut-away showing the general constructional features of one of the cooling units.

**Fluid Cooler Dept. The Trane Company, La Crosse, Wis.*

DIESEL BRIEFS



Power Plant for Arc Welders

The McDowell Company, Inc. contractors and engineers, have designed and built an unusually economical source of power for electric drive arc welders. McDowell has constructed two of the units to use on their construction jobs where regular power installations are not practical.

The compact unit is comprised of a diesel driven generator and six standard, motor generator, DC welding sets as manufactured by The Lincoln Electric Company. The welders and power unit are built into a special sled which is readily transported to the job and which can be rolled along on pipe rollers, if it is necessary, as the job progresses.

The UD24 International diesel engine drives a 100 kw. generator which produces 220 or 440 volt, 3 phase, 60 cycle power. The generator has a capacity to operate six 300 ampere welders simultaneously with adequate reserve to run eight welders if desired.

The operation of two such units on a bridge repair job recently done by McDowell proved to be considerably cheaper than operating twelve gas engine welders. The two diesel units consumed approximately 52 gallons of fuel oil a day, which resulted in a power cost of one cent per kw.

Diesel Locomotive Savings

An estimated $31,000 will be saved annually in fuel costs alone through the use of eight General Electric diesel-electric switching locomotives, according to officials of the Administracao Do Porto De Rio De Janeiro. The locomotives, six 45- and two 65- toners, replaced steam motive power in October, 1948.

Fuel consumption performance records show that annual fuel savings will average more than $10,000 per unit. At this rate, officials estimate that the switchers will pay for themselves out of fuel savings in about three and a half years. Average fuel consumption for the 45-ton units has been 1.47 gallons per hour of operation; for the 65-tonners it has been 2.76 gallons per hour.

For one period, the number of locomotive hours was increased about 49 per cent over the old steam units, yet total fuel cost was 41 per cent lower. Officials of the Administracao Do Porto estimated that if locomotive hours had been the same, comparing the new G-E diesel-electrics to the old steamers, total reduction in fuel cost would have been around 61 per cent.

New Firm

The Hill-Johnson Engineering Co. has been formed by Mr. Harry O. Hill and Mr. Robert S. Johnson. The firm is located in Lake Odessa, Michigan. The new firm will specialize in consulting, design and development of diesel engines, combustion chambers, fuel metering equipment, hydraulic devices and power controls. Complete drafting service is also available.

Mr. Johnson was a member of the Timken organization when they were designing and developing fuel injection equipment, and was later Assistant Chief Engineer and designer for the Diesel Engineering and Manufacturing Co.

Mr. Hill was with Hill Diesel Engine Company for approximately 15 years and subsequently spent 11 years with the American Bosch Corporation as a Field Engineer and later as manager of their Gasoline Injection Division.

GM Service Office

Rapid growth in application of General Motors locomotives on Eastern railroads has necessitated the opening of a new service office by Electro-Motive Division, it is announced by N. C. Dezendorf, Director of Sales.

The new headquarters, to be known as the Washington Regional Service Office has been opened in the Transportation Building in Washington, D. C. All Electro-Motive service activities for railroads in the southeastern section of the country will be directed from this point by Mr. F. H. Albert, newly appointed Regional Service Manager.

The territory served by the new office heretofore has been handled by the New York Regional Service Office. Railroads in the northeastern segment of the country continue to be served out of New York, under the direction of Mr. W. A. Turner, former assistant Regional Service Manager, now promoted to Regional Service Manager.

FULTON IRON WORKS CO.

FOUNDED 1852 INCORPORATED

ST. LOUIS (11), MO., U.S.A.

A STATEMENT TO OUR CUSTOMERS AND FRIENDS

Recently the management found it expeditious to get rid of certain machine tools in our shops which were considered surplus. As was expected, this led to certain rumors to the effect that the company was discontinuing all manufacturing operations. To paraphrase Mark Twain, the rumors were highly exaggerated.

Actually, the company will continue operations here, as in the past, fabricating in its own shops, and with its own personnel, orders received covering complete Diesel and Dual Fuel engines or spare parts thereof.

The same exacting supervision and control by our experienced technicians continues without interruption.

Our unexcelled Engineering and Service Departments will continue to cooperate with our clientele to solve any problems that might come up and recommend remedies for situations that require such attention.

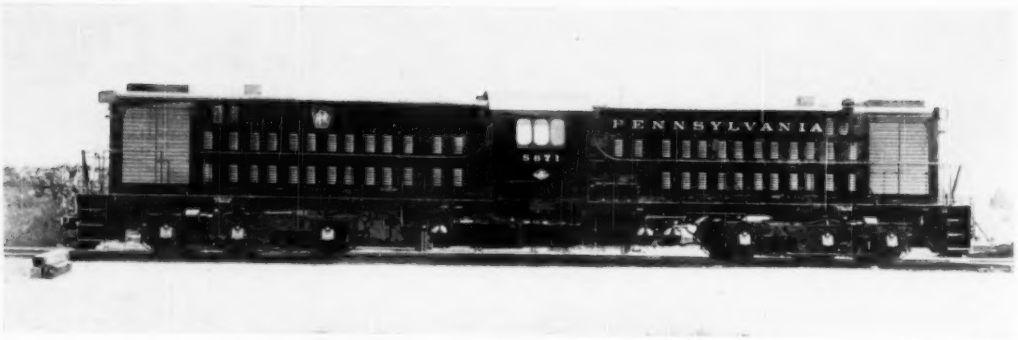
The customary FULTON guarantee of quality, labor and materials will apply in the future as it has through the past 98 years of successful operation.

Needless to say, Fulton would be grateful to receive any of your inquiries for complete Diesel and Dual Fuel engines or spare parts thereof.

FULTON IRON WORKS COMPANY

F. E. O'Neil

F. E. O'Neil
President



The new 2500-hp. Lima-Hamilton switcher recently delivered to the Pennsylvania Railroad.

New Lima-Hamilton Switcher Model

LIMA-HAMILTON Corporation has delivered to the Pennsylvania Railroad the first of eleven 2500-hp. diesel-electric transfer locomotives on order for the Pennsylvania. The new diesel-electric is the first 2500-hp. locomotive built in this country, and is the second largest diesel-electric ever built as a single unit.

At the same time, Lima-Hamilton announced that in addition to its 800 and 1200-hp. switchers, it has added a 2400-hp. unit to its standard line. This new locomotive is similar in many respects to the 2500-hp diesel built for the Pennsylvania. These three locomotives—the 800, the 1200, and now the 2400—currently round out the firm's diesel locomotive line with units suitable for all kinds of hauling for road, yard, and general industrial service within the capacity of the individual locomotive.

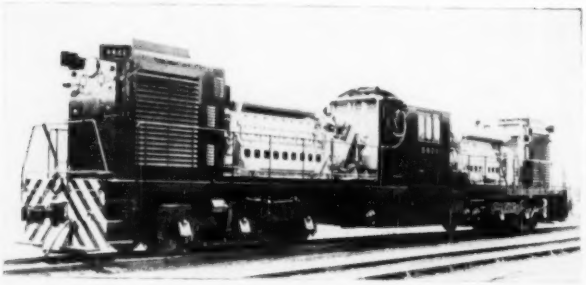
The locomotive is powered by two eight cylinder, 9 by 12 in. diesel engines which are super-charged to develop 1250 hp. each. The super-charging is accomplished by use of an Elliott turbo-charger, and is accompanied by intercooling of the super-charged air between the charger and the engine intake. This intercooling of intake air, which produces lower temperatures throughout the cycle, helps keep maintenance down. The diesel engine, and all its parts, are also interchangeable with the engines in the 1200-hp. locomotives.

Of steeple cab design, the 2500 diesel is of the C-C wheel arrangement, with the single cab mounted on the frame which is carried on two six-wheel side-equalized swivel trucks with a motor on each axle. The operator's compartment is located in the center of the locomotive, with a power plant hood extending to either end of the unit. The rating of 2500 hp. is the combined bhp. of the two engines. The locomotive, which weighs 130 tons in working order, has a maximum speed of 65 miles per hour.

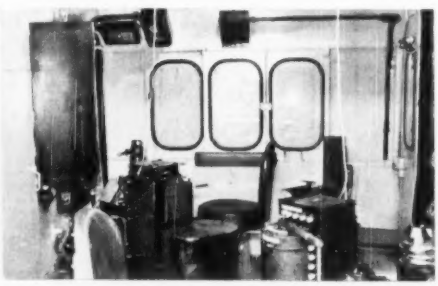
Starting tractive force of the locomotive (30 per cent adhesion) is 103,000 lbs. Maximum height to top of cab is 14 ft., 6 in., while the maximum width over brake cylinders is 10 ft., 2 1/8 in., and over hand rails is 9 ft., 11 1/8 in. Length inside coupler knuckles is 79 ft.; distance between truck centers is 49 ft.; truck wheel base is 13 ft.; total wheel base is 61 ft., 3 in., and the diameter of the wheels, 42 in. The various capacities are as follows: fuel oil, 1250 gal.; cooling water, 450 gal., and lubricating oil, 290 gal.

With few exceptions, all locomotive components of the new 2500-hp. unit, such as the hood, operator's compartment, trucks, underframe, pipe and fittings, lighting system, and other

View of the new switcher with side panels removed.



Interior of the control cab showing both sets of controls and control panel.



miscellaneous parts, are similar in construction to components of the 800 and 1200-hp. models. Trucks, for example, are of one piece steel castings, equipped with plain bearing journal boxes, and the underframe is of welded construction.

Entrance to the thoroughly insulated operator's compartment, located as it is in the center of the locomotive, is through a door on either side which gives access to the runboard. Sliding windows are provided on each side, while front and rear windows are of the fixed type. All windows and doors have safety plate glass, which is mounted in special key type rubber channels, offering easy removal of glass and maximum safety for personnel against any injury due to accidental breakage.

Differences between this and other Lima-Hamilton locomotives are found in the air brake equipment and in the trucks. The air brake equipment is a 24 RL dual station, automatic and self-lapping straight air brake. The trucks are six wheeled. The Westinghouse electrical equipment, which is used throughout, features six Type 370-DL traction motors, series type, axle hung, forced ventilated, and equipped with single reduction gearing which drives the locomotive. Other electrical equipment includes two main generators Type 499-B, two exciters, two fan generators and two traction motor blower motors.

Controls are electro-pneumatic, with two stations for the operator. The controls are used with a Woodward type governor and governor operator, and a Woodward type load control using a face plate type rheostat. Traction motors are connected in two groups of three in series across the generator. Two steps of field shunting are provided with automatic switching. There is push button control of lighting and other auxiliary apparatus. Compressed air for electro-pneumatic apparatus is 70 psi., while wheel slip relays operate a light, warning the engineer when slipping of a pair of wheels occurs.

Important Information About—

H-D Oils and Mechanical Lubricators

PROGRESS IN one field of endeavor sometimes creates problems in others. A good case in point is some technical information recently disseminated by the Sinclair Refining Company relative to the use of heavy duty oils in mechanical lubricators.

Detergent type oils were developed to meet specific conditions of engine operation and have proved invaluable in certain types of engines, principally those of the high speed type. Now it appears that the growing use of detergent-type oils for cylinder lubrication in the larger, slow and medium speed diesel engines has uncovered an aspect with respect to sight-feed glasses of mechanical lubricators that is not widely understood among engine operators nor by all service representatives of the engine builders.

It has been general practice to fill these sight-feed glasses with glycerine or a glycerine-water mixture; and this is entirely satisfactory when straight mineral oils are used for the lubrication of the cylinders. However, the compounds, particularly the detergent additives, incorporated into heavy duty type oils have a tendency to react with the glycerine to form gummy or resinous substances which cause trouble.

This may first appear as a haze or cloud which will probably be passed off simply as annoying because visibility is impaired; but if allowed to continue, the gummy material that has formed completely clouds the glass so that visual assurance of oil delivery is made impossible. Also, the gummy substances may be picked up by the drops of oil and carried on into the oil lines leading to the cylinders. Cases have been reported where such substances were found in the oil lines to the extent that the passages were restricted.

This reaction has been reported to and observed by lubricator manufacturers and they in turn have investigated the problem to determine what fluids should be used in the sight glasses when detergent-type oils are used. Unfortunately, operators may change from a straight mineral oil to a heavy duty type without realizing that this condition will develop. Also, the manufacturers of the lubricator and the engine builder are often not aware that this change in lubricant has been made, so they cannot offer their advice.

It is natural for operators to want to avail themselves of the benefits of the heavy duty oils to obtain cleaner pistons, free rings, reduced deposits, etc. The answer, then is not to stop using the oils but to see how they can be safely applied.

The Sinclair laboratories investigated the problem on the basis of determining a suitable fluid, free from reaction with the additives, to substitute for the conventional glycerine solutions. Different brands of oils use different additives and it was found that while a number of fluids for this purpose were satisfactory with one oil they were unsuitable with others.

Included among the fluids tested were ethylene-glycol-water mixtures and *Windex*, a proprietary product for cleaning glass. The first varied little in results from the glycerine-water solutions and the second, while showing considerably better results, was not felt to be the answer. The silicones were found to give the best results and the final recommendation was for the use of Dow Corning Fluid 200. This fluid produced no reaction with any of the additives and appeared to be entirely satisfactory for the purpose.

San Diego Enlarges Sewage Treatment Works

by Milo D. Pugh

EARLY THIS year, the enlarged and extensively remodeled San Diego Sewage Treatment Works was put into service under the supervision of Eric V. Quartly, Superintendent. The plant was originally built in 1943, and with the enlargements and improvements represents a total investment of about $3,500,000.

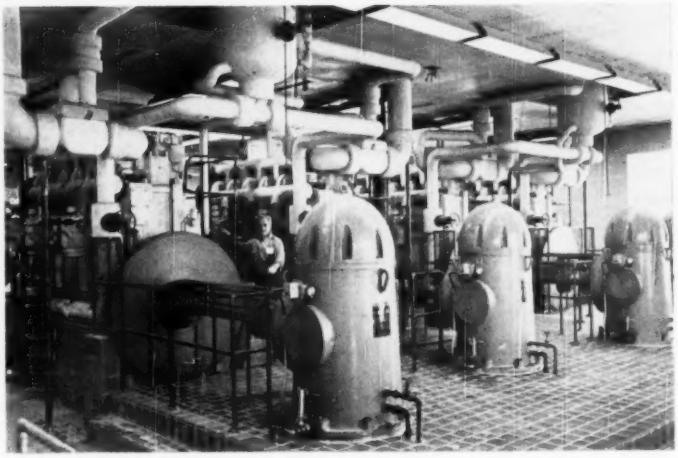
The initial plant, when designed, was expected to be sufficient to take care of the city for many years to come. However, the unexpected growth of the city during and since the war, necessitated enlargement and it was decided to change from electric power, to power which could be produced in the plant by utilizing the sewage gas for fuel. The gas had previously not been fully utilized.

In addition to a new power plant, the improvements consist of a new administration building and two new combined aeration and sedimentation units. The three settling tanks of the original layout were converted into digesters and the flow rearranged to provide greater efficiency and economy in addition to the saving through the use of sewage gas. The ultimate savings will not be fully realized until the plant is required to operate at near capacity which will be some time in the future.

The plant is designed for an average daily capacity of 40,000,000 gallons of sewage with a peak capacity of 70,000,000 gallons daily. This will take care of a population of over 400,000 and an industrial population equivalent to 100,000 additional.

As the plant is now laid out, the raw sewage enters the plant through a 60-inch RCP interceptor sewer and a 36-inch VCP interceptor sewer to a raw sewage inlet structure. From there it goes to a mechanical bar screen to remove coarse material and debris. The coarse material after being ground in a Chain Belt Company titurator is returned to the main flow.

The sewage passing the screens goes to a wet well from where it is pumped through venturi meters to the aeration tanks then to sedimentation tanks. The sewage effluent is here discarded, and the raw sludge is again pumped through venturi meters to two-stage digesters which take care of the primary and secondary sludge. The sludge then passes through rate-of-flow controllers then to primary and secondary elutriation tanks from where it is pumped to sludge conditioners. The wet sludge then goes through vacuum filters and finally to Raymond Flash dryers where it is dried and sacked as fertilizer.



Engine room of the new sewage disposal works showing the four Enterprise engines and the pump drives.

The gases that are produced in the primary and secondary digesters are stored under floating steel covers on top of the digesters for engine fuel. To dissipate possible odors, a central ventilation system is provided and a high stack carries off objectionable odors well above the surrounding area.

Equipment

The power plant consists of 4 Model GSG6 Enterprise 6-cylinder 12 x 15 in. bore and stroke engines operating on sewage sludge gas. While rated at 360 hp. at 400 rpm., these engines will operate at speeds of between 290 rpm. and 400 rpm. Each engine drives a Fairbanks-Morse pump through a Western Gear Works right angle pump drive with a 1.45 to 1 ratio.

Each pump has a capacity of 22,500 gpm. at full load or a total of 90,000 gpm. for the four pumps. They are automatically controlled by the level of the water in the wet well. The Western Gear pump drives have forced, positive feed lubrication to all bearings and to the gear mesh by means of a positive displacement lubricating oil pump located in the oil sump and is gear driven off the main gear shaft. This assures an adequate supply of oil to properly lubricate and cool all gears and bearings under a wide range of operating speeds and loads. The main power transmitting gears are curved tooth spiral bevels of alloy steel forgings, carburized and lapped to give smoothness, quietness and maximum load carrying capacity.

The gage board of each engine includes a Weston tachometer, a lube oil pressure gage, a starting air pressure gage, a circulating water pressure

gage, and a gas pressure gage. These gages are by Marshalltown Manufacturing Co. Installed in the gas supply line is a Fulton-Sylphon safety controller which will automatically cut off the fuel in case of lube oil pressure failure.

Each operation of the plant is carefully checked by means of instruments. In the power plant for the guidance of the operators, are large indicators which can be read from almost any point in the engine room. These are by Builders Providence and show sewage flow, quantity of effluent discharge and the amount of air to the aerators. In the administration building is a large instrument board with many other instruments to provide a check of all other operations.

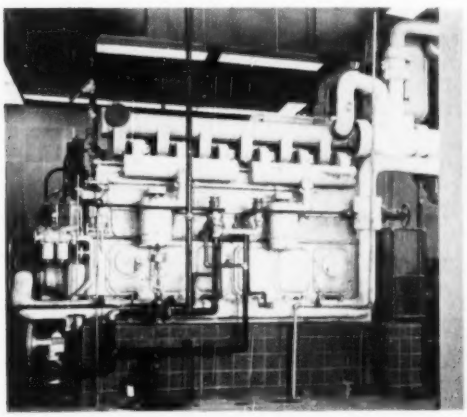
The instrument board in the administration building. Gages on the wall provide a check on the operation of the plant.

In addition to the four pump engines, there are two Enterprise engines of the same model but rated at 324 hp. at 360 rpm. each direct connected by a flexible coupling to a Sutorbuilt blower with a capacity of 7500 cfm. each at 7½ psi. Butane-propane is used as a stand-by fuel. All engines are equipped with "Vapor Phase" system of cooling furnished by Engineering Controls, Inc.

The untreated sludge gas contains H_2S which normally cannot be used in engines due to the corrosive effect on the cylinders, valves, etc. It also causes lube oil sludge. In this installation the high temperature is said to eliminate condensation in the cylinders enabling safe use of the gas without acid-removing treatment. Also with no condensation, the lube oil is not contaminated so that it maintains a perfect film over all surfaces to be lubricated, thus wear is reduced to the absolute minimum.

In the "Vapor Phase" system the engine circulating water is never cooled, therefore it must boil all of the time. The elevated water temperature prevents condensation from the products of combustion, as both inlet and outlet water is always boiling, thus, the entire engine water jackets are above the dew point of the gases in the combustion chamber, which dew point is about 194 deg. F. The H_2S in the gas requires moisture to make acid and with no condensation there is no moisture.

Side view of the blower engine and blower.



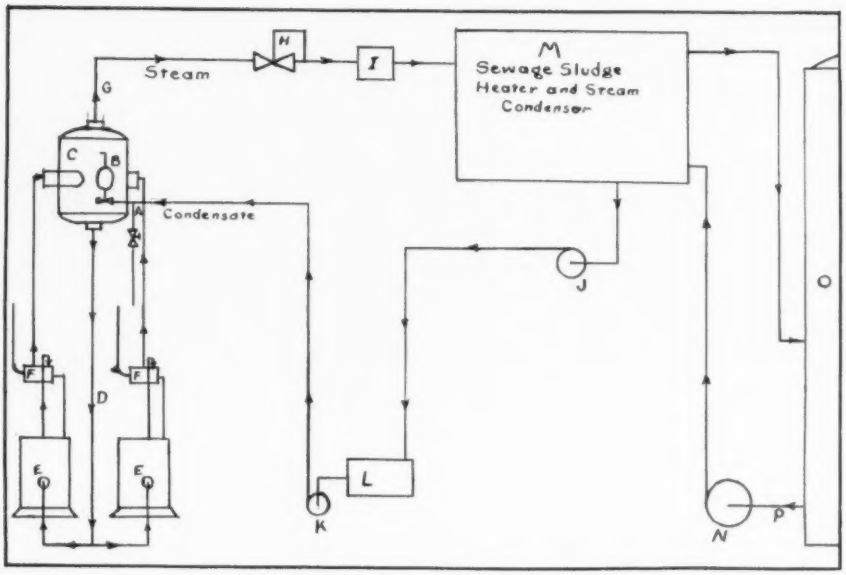
Waste Heat Recovery

This system is designed to recover all of the heat rejected to the engine jackets, radiation neglected, plus about 50 per cent of the exhaust heat. In order to capture as much radiated heat as possible, the units, exhaust boilers and all hot water and steam lines are insulated with 85% magnesia covering.

The recoverable heat from normally aspirated four cycle sludge gas engines when equipped with water cooled exhaust manifolds is in the order of 2910 Btu's per bhp.-hr. from the jackets plus 1455 Btu's per bhp.-hr. from the exhaust or 4365 Btu's per brake horsepower per hour total. The system recovers this heat, normally wasted, in its most useful form, i.e. low pressure steam. In this case, the steam pressure is maintained at about 5 psig or 227 deg. F.

Each engine when operating at full load of 350 hp. will generate steam at the rate of 4.5 pounds of steam or 4365 Btu's per brake horsepower per hour or 1575 pounds of steam or 1,527,750 Btu's per hour. When all six engines are operating at full load of 350 hp., a total of 9450 pounds of steam or 9,166,500 Btu's per hour is recovered for useful work.

In the treatment of sewage sludge, heat is required to break down the solids and make sludge gas, which heat, formerly generated in gas-fired boilers, is in this case all supplied by



Drawing of cooling system used in the plant. Operation of the system is explained on this page.

the "Vapor Phase" system which serves the dual purpose of cooling the engines and at the same time recovering the waste heat for the sewage treatment process.

Operation

To start the system, (see drawing) the plant water supply *A* is turned on. The automatic water make-up valve *B*, which maintains proper water level in the engines and system at all times, will shut off the water when the engine jackets and the system is filled.

The engines are then started. The engine circulating pump *E* is flooded by the inlet water line *D* and "Vapor Phase" unit *C*. As the water passes through the engine, it picks up the heat rejected to the jackets, then passes through the exhaust boiler *F* where it picks up the exhaust heat, then to the unit *C* where the recovered heat flashes to steam.

The unit *C* separates the steam from the water. The steam passes out line *G*, and the water passes back to the engine. The steam and circulating water in this case is maintained at 5 psig. or 227 deg. F by the steam pressure regulating valve *H*.

Cooling of the engines is accomplished by transferring the engine heat to the sewage sludge through de-superheater *I* to sewage sludge heater *M*, thus transferring all engine heat to the sewage sludge. In order to reduce the heat of the steam and minimize caking of the sludge on the outside of the heater or heat exchange tubes, a vacuum is applied by vacuum pump *J* which reduces the temperature of the steam in the tubes to about 140 deg. F. The condensate collects in the hot well *L* and is returned to the unit *C* by condensate pump *K*. Thus, the engine water circuit is completely closed.

Do You Need Trained Diesel Men ?

A card to DIESEL POWER AND DIESEL TRANSPORTATION will bring you our listing.

There are four primary sludge digesters, each having a sludge heater or heat exchanger *M*. These heaters each have a capacity of 4,000,000 Btu's per hour. The four heaters being larger than required to cool the engines, permits flexibility of operation and allows for taking the heaters off the line one at a time for servicing.

The cold sludge is pumped into line *P* at the discharge of the sludge circulating pump *N*. All sludge is continuously circulated through digester *O* and heater *M* to maintain the desired sludge temperature.

While the heat exchangers used in this plant are of the new vacuum type, the system has been used in sewage plants for more than ten years. The first "Vapor Phase" system built for sewage gas engines is still in use after more than 90,000 hours of engine operation, and the engine still has its original cylinders and pistons.

Conclusion

The San Diego Sewage Treatment Works will, when fully landscaped, compare favorably with any of our present day industrial plants. It is an outstanding achievement in plants of this type and is considered one of the finest in the world. It is a credit to the city and to the designers and builders.

Indiana Harbor Belt Completes Diesel Program

THE INDIANA Harbor Belt Railroad, unique Chicago property which serves as the connecting link between 28 other railroads, has completed its program of dieselization. One hundred and 18 diesels now handle more work than that formerly accomplished by 154 steam engines.

Complete dieselization of the railroad at a cost of approximately $15,000,000 is paying off, according to Robert H. McGraw, a railroad fireman who rose from the ranks to become General Manager of the IHB. The railroad is now showing steady earning power for the first time in some 18 years.

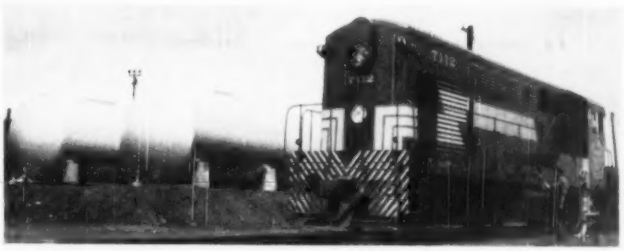
Mr. McGraw first started to sell his program of complete dieselization to his board of directors four years ago. The project was approved and a period of testing various types to suit the unique needs of the IHB was started. Finally, on Jan. 30, 1943, the first unit was delivered to the Gibson yards.

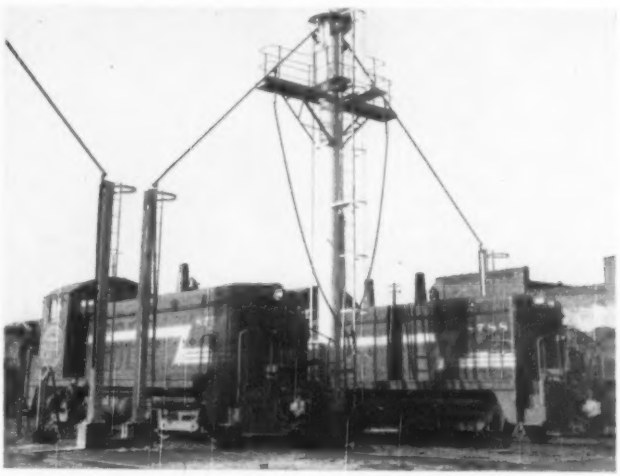
In order to effect the greatest economy possible, the IHB decided to use the same type of power throughout its 124-mile system. Mr. McGraw believes that this eliminates costly duplication of parts and simplifies maintenance. Furthermore, in converting his railroad he did it by sections in order to realize the greatest economy.

Gradually, month by month, the diesels were added until April of 1950 when the program was completed.

The capacity of the IHB was once rated at 6000 cars daily. Before the program was completed, the railroad succeeded in handling more than 7000 cars daily. The diesels have reduced operating costs and boosted efficiency. The railroad no longer uses the 325,000 tons of coal required annually and has eliminated water costs which ran into the millions.

Mr. McGraw points out, too, that the safety record has improved for both employes and the public. Housewives who used to shake their fists at the smoke-belching steam locomotives that soiled their newly-washed clothes and dirtied their homes, now wave friendly greetings at passing trainmen.





Above—a switcher at one of the refueling stations of the IHB line and (below) two switchers taking on fuel and sand at another station.

At the present time the diesels have a 95 per cent availability, as compared with 60 per cent for their predecessors. Flexibility is greater—the engines can go anywhere a railroad car can go—and refueling time has been cut 30 per cent.

To maintain its 118 diesels, the IHB has a main shop at Gibson employing 124 men. Here traction motors are replaced, the diesels are inspected, lubricated, air and oil filters and wheels replaced and all except major overhauls accomplished. The engines are refueled at various places on the railroad and diesel mechanics, traveling in trucks, make minor repairs all over the railroad as well as making inspections of equipment.

General Manager McGraw expects his diesels to last nearly a decade. The IHB has no facilities for heavy overhauling but when heavy overhauling becomes necessary, it is entirely possible that the road will make use of the facilities of the New York Central, its parent company, at Niles, Mich.

In view of the fact that it serves 28 other railroads—believed to be more than any other railroad—the IHB is a unique property in itself. It is actually a belt line around the southern part of Chicago; a switching railroad. In addition to the yards at Gibson, where 1300 of its 3500 employes are centered, there are also yards at Calumet City, Blue Island, Argo and Norpaul. It's 124 rail miles run from Hammond, Ind., to Franklin Park, Ill.

Portable Diesel Sawmill Operation

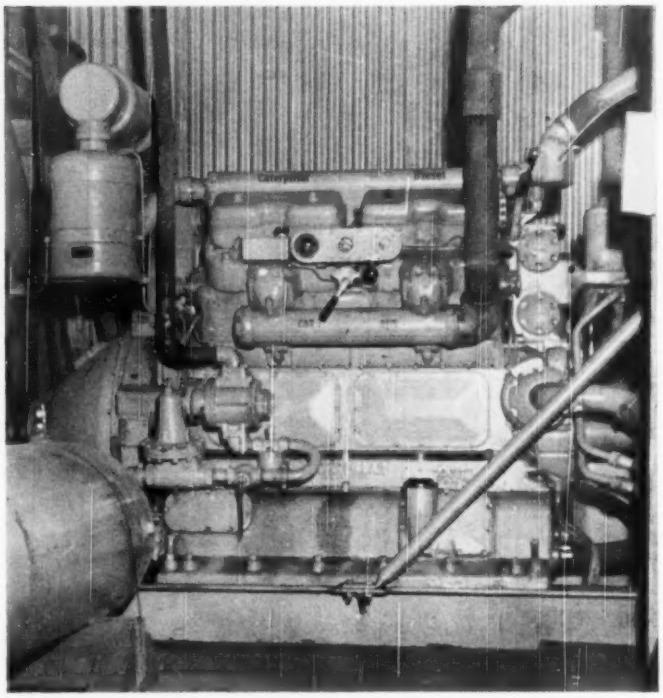
by W. J. Granberg.

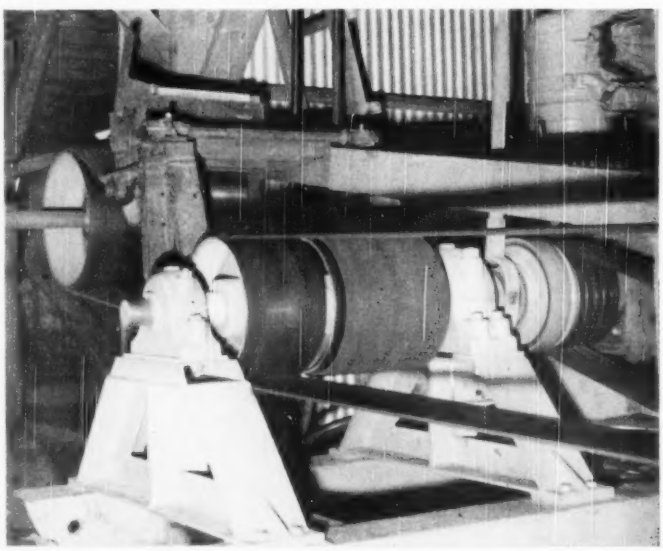
BRINGING THE sawmill to the forest instead of making long and costly log hauls to mills far from the skidroads is proving feasible for a western logging outfit which is utilizing diesel power at its mill beside a lake, far from a highway. One of the outstanding features of the mill is that the power plant is portable and can be moved to a new site, if and when desired, to meet the supply of logs.

With logging operations steadily moving farther into the forests, and at higher altitudes, portability of a sawmill power plant is becoming increasingly important. On the economical side is the fact that smaller logs, cut from trees that ordinarily would be disdained by a big-time operation, can be cut profitably by a sawmill set up near the source of timber supply. This means that more timber is being utilized, not merely the prime trees, and that the entire lumbering picture is improved economically.

The factor of portability, along with economy of operation and assurance of an even, constant source of power, mark the backwoods operation of the Rudy Brothers Logging Company which has brought the mill to logs in Washington. The sawmill is situated at the east end of Silver Lake, about seven miles east of Castle Rock, and is served by trucks which dump the logs into the pond at the foot of the mill.

The power plant is a V-8 Model D-375 Caterpillar diesel engine which turns out 340 hp. at 1200 rpm. Ordinarily, the engine operates at about 1100 rpm., putting out 290 hp. At this speed, fuel consumption amounts to about eight and one-half gallons per hour. The engine is mounted on a double runner steel sledge base to make moving it a relatively easy chore. It is water cooled, with a Modine system, and is equipped with a Twin Disc clutch. Weight of the engine alone is 8550 lbs., with the clutch adding 2150 lbs. and the radiator 1150.





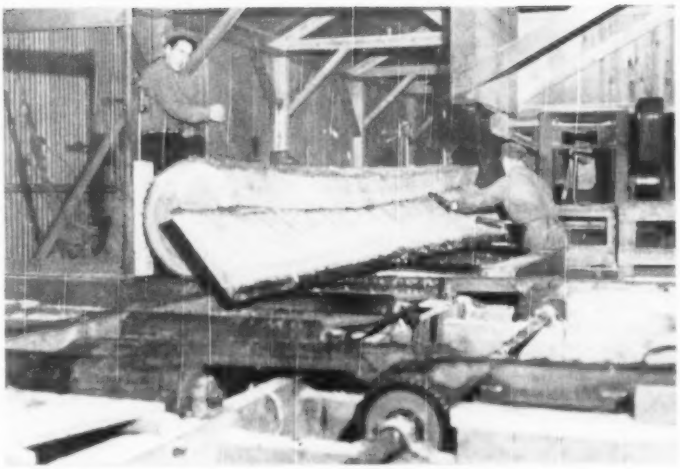
Above—The model D-375 Caterpillar engine which powers the entire sawmill and, below, details of the power take-off from the engine.

Together with the sledge, the aggregate weight of the power plant thus comes to about 13,000 lbs.

Unusual ingenuity was displayed in using all possible power from the Caterpillar engine in turning the sawmill machinery, and what is not turned with power taken directly off the shaft is motivated by electric motors served by the 60-Kw. E-M generator linked to the engine by a V-belt. The generator is equipped with an E-M Synchrostat voltage regulator.

The headrig, including log carriage and 52-inch head saw, and the edger and transfer chains are powered directly from the diesel's drive shaft. A 15-inch belt runs to the line shaft on the headrig, with a 10-inch belt going to the edger, plus the belt to the generator. The main conveyor in the mill overhead is driven by a six-inch belt from the headrig's shaft on a pulley take-off. The engine and belting are under the floor of the mill, which stands high above the ground level and are easily accessible, as are compressor and generator.

The generator powers seven electric motors, having an aggregate of 33 horsepower, to operate the following equipment: log lift from pond, 20 cu. ft. compressor, transfer chains to edger, the green chain, edger to trim saw transfer, two-saw trimmer, and slab saw. The Ingersoll-Rand compressor not only provides air for starting the diesel engine, but activates the edger rolls and the kickers on the transfers.



Traveling log carriage powered by the diesel. Belts in right background carry power from the engine for the rig and the mill's main conveyor.

Rudy Brothers, rebuilding to replace a mill that was burned out last fall, got into production in February and this spring were producing 50,000 feet of lumber in a 10-hour shift. It is believed to be the first sawmill operation in the west to use the new Caterpillar D-375 engine. Although there is so much noise around a sawmill that a little more would not be noticed, the noise level of the diesel was reduced by a silencer on the blower intake. The area under the mill floor is open on all sides and there is plenty of head room and light.

ASME Baltimore Meeting Outstanding

CONSIDERABLE satisfaction was expressed by those in attendance at the 22nd Oil and Gas Power Division, ASME Conference recently held in Baltimore. It was felt to be one of the most constructive meetings held in recent years.

The special OGP Lectures, dealing with the subject of corrosion, were well received and atttended. Dr. Mears, Carnegie-Illinois Steel Co., discussed the fundamentals of corrosion and, if so complex a subject can be summarized, his theme was that corrosion is essentially an electro-chemical phenomena. Solution to the problem was offered as being the elimination of bimetallic couples, temperature differentials and similar conditions resulting in potential differences.

Mr. Wilkes, Dearborn Chemical Co., followed with a discussion of water jacket corrosion problems. He ably pointed out the necessity for water treatment and outlined the role of the chromates as inhibitors. Mr. Schrader of the U. S. Naval Engineering Experiment Station discussed corrosion in the engine cylinder. His talk largely concerned the sulfurous fuel problem and means for combatting it. In addition to the use of the Series 2 lubricants, the advantages of operation at elevation were brought out.

Three Technical Sessions and two Panel Discussions comprised the regular Technical Program. The Marine Panel on the topic of propulsion drives for diesel vessels consisted of authorities from the American scene and also included Mr. E. Englesson, chief engineer and designer of the KaMeWa controllable, reversible pitch propeller, so popular in Europe. This gentleman came from Sweden to participate.

Use of heavy fuel was discussed at the second Panel. The topic was explored from the angle of the types of fuels, points of availability and price. Three panel members, all with considerable experience in burning heavy fuel, commented on their operations. Again briefing an extremely complex problem, it was concluded after discussion that use of the heavier fuels was both practical and economic but that each case was an individual problem. Such matters as the types of fuel locally available and their cost differential must be determined and the expected fuel bill savings correlated with any increased maintenance cost.

There were inspection trips to the Koppers Company piston ring facilities and the shops of the Baltimore Transit Company. High point was the boat trip to Annapolis for the inspection of the Naval Engineering Experiment Station.

Valve Problems in Diesel Engines

*by Vincent Ayres**

YOU HAVE heard the statement that the problems of fuels, lubricants, and engines are inseparable and the valve gear is one part of the engine which is definitely included in this statement. This paper is intended primarily to cover the valve problems; therefore, the design of the valve gear will be discussed only as it affects the valve.

The definition of a valve problem is any function of design, operation or maintenance resulting in premature failure of the valve, or impaired engine operation. The problems with which we have been confronted in diesel engines might be listed in their order of importance as follows:

(1) breakage
(2) seat wear
(3) valve face guttering
(4) stem and guide wear
(5) sticking

These problems will be presented and possible solutions suggested for the benefit of the engine manufacturer so that he may have aid in analyzing his problem and so that the operator and maintenance crew can appreciate why it is necessary to perform certain maintenance operations which might seem difficult or expensive.

Valve Breakage

A valve breakage can be disastrous if it completely wrecks an engine; and after the failure has occurred, it is difficult to determine the cause.

One sequence of events occurred when a valve broke and went through the top of a piston. The piston jammed and broke the crankshaft which, in turn, punched out the side of the crankcase. The engine was locked in gear and with the help of the truck driver's foot on the brakes, the rig was stopped. In the process, a load of steel on the second trailer broke loose, severed the trailer hitch and went into the pavement with enough impact that the shock was felt in the company's money box when the repair bill was received from the city.

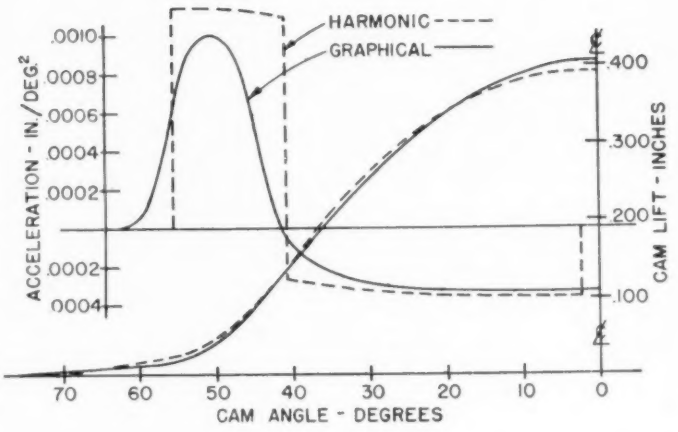


FIG. 1

Typical lift and acceleration diagrams for graphical and harmonic cam designs.

Valve breakages can result from improper installation as well as borderline designs. Improper installations are difficult to trace unless repeated, but borderline designs can be traced since the failures are usually of the fatigue type. Fatigue breakages may occur at several locations on the valve depending upon design, and we might consider the causes that will lead to this form of destruction.

These are: (1) abnormal loading of the valve, or (2) a design which lends itself more readily to fatigue failures. Abnormal loading can result from overspeeding the engine, or may be present after wear has occurred in valve train parts increasing lash. The manufacturer designs a valve train for a given set of operating conditions but engines differ in their ability to operate well when these conditions are varied.

Overspeeding, while not common in diesel engines, can occur if the engine is used in a vehicle, especially downhill, or if the operator adjusts the engine so that higher speeds may be obtained. One known case was that of an operator who found he could move a much heavier load if the engine was operated 200 rpm. higher than normal, but the engine broke valves when operated at this higher speed. Manufacturers are charged with the responsibility for designing valve trains with a factor of safety for overspeed. To design a valve train for higher speeds it is necessary to consider more than just the structure of the valve even though the valve might be the weakest member of the valve train. An improved valve in this instance may result in a slight increase in life before the breakage occurs at some other point on the valve or in the valve train.

One remedy which has resulted in raising the normal operating speeds of engines successfully is to improve the valve motion. A study of the valve train deflections will uncover any weaknesses in the system. Such a weakness may be found in the push-rod, rocker arm, rocker shaft or rocker shaft support. If the thought is kept in mind that rigidity is more important than weight in diesel valve trains, the next step can be approached.

That is, redesigning cam contour for the purpose of eliminating exces-

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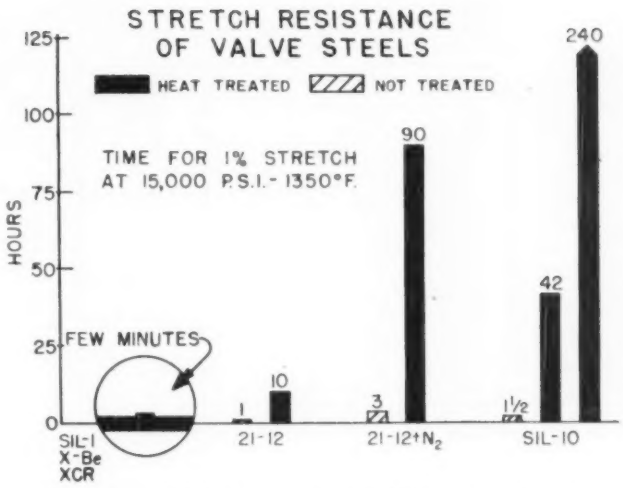
sively rapid changes of acceleration which are kin to impact. M. C. Turkish in his treatise "Valve Gear Design" discusses a semi-graphical method of cam design.Through the use of this method, a slightly modified lift curve designed with an eye on the acceleration diagram can reduce theoretical impact values from infinity to values which the valve train can withstand without undue deflection and vibration. This type of cam design is now common in automotive gasoline engines and is gaining in its use in diesel engines.

Typical lift and acceleration diagrams for graphical and harmonic cam designs are illustrated. The designs used for illustration are the old and new provided on a diesel engine having approximately 200 cu. in. displacement per cyl. operating at 1200 rpm. The harmonic design included a dwell of 5 deg. at the nose joined by nose radii of 0.130 in. The acceleration of the harmonic design was typical with square corners. Theoretically, this design requires the gear to change from zero acceleration to maximum acceleration in zero degrees.

Force is equal to mass times the acceleration and if the latter is changed at a very high rate, then the force is changed also at this rate. This is known as impact, and in a valve gear is actually a blow which starts the gear vibrating. This vibration will have amplitude, frequency, and rate of decay proportional to the striking force, stiffness, and damping characteristics of the system. It is not uncommon to have this vibration exist all through the lift cycle and cause high valve seating impact with possible breakage.

Sifice the cam determines the motion it can be made to push instead of strike the valve gear. The graphic design shown requires approximately 10 deg. cam travel to change from zero to maximum acceleration and pick up a load of 250 lbs. A higher maximum acceleration is possible with this type of contour because the rate of load application is low, but a lower acceleration was used in this instance. The cam angle is wider but the lift curve is only slightly affected. By eliminating the dwell and increasing the nose radius to 0.222 in. the lift was increased and the tappet stress reduced.



The improvement of hot stretch resistance resulting from heat treatment applied to austenitic valve steels.

Measurement of actual loads in the valve train through the use of a resistance wire strain gauge on the rocker arm or push-rod is recommended as a means of comparing design. Abrupt changes of load are easily detected and improvements in cam design will evidence themselves by a smoother loading diagram more closely approaching the theoretical and in freedom from extreme changes of load value. Other benefits may be reduced valve spring load requirements, reduced spring vibration and breakage, larger cam nose radii, all of which reduce tappet face stresses; reduced camshaft torques which benefit timing gear life; and less valve train noise through the speed range.

Wear in the valve train parts may contribute to breakage if the velocity of valve seating is increased. Minor effects are seat wear and dishing of the valve. I refer here to wear which might occur on the tappet face, cam lobe, rocker arm, valve tip, or valve guide. In computing required ramp heights for cam designs, consideration is given to lash and the amount of ramp required to compensate for maximum cocking of the valve, but if these values are increased through wear, then the designed ramp height becomes inadequate to control valve seating. The use of hydraulic lifters as a means of lash control has been accepted by the industry, and in conjunction with improved cams, has contributed toward reduced valve breakages.

Valve Structure

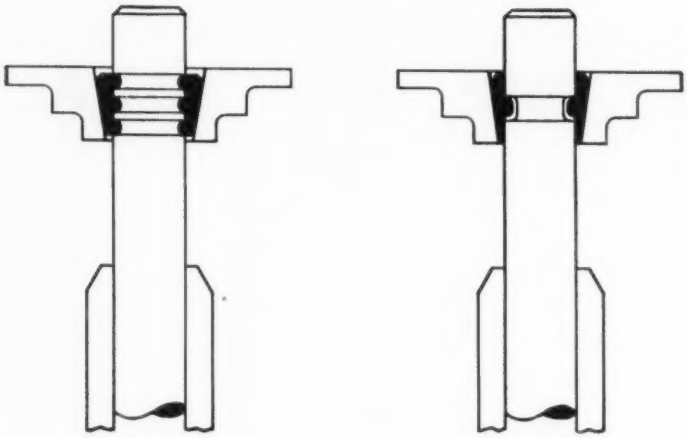
A study of successful valve designs will disclose some common features, and departures from these tenets might show up as valve weakness.

The valve head section should be rigid enough to support the gas load without undue deflection. Mass of the valve head may not be the complete answer since the strength of the valve material at the operating temperature is also involved.

The valve rim should not be too thin because a thin section will have a greater temperature fluctuation leading to a thermal fatigue evidenced by cracking, splitting, or curling.

A decently wide seat contact is good practice with as little of the valve head as possible extending beyond the seat into the combustion chamber. A large portion of the valve heat is carried through this contact.

A generous underhead radius with no abrupt changes in section at the junction of the head and stem will reduce the concentration of stresses in this area. Fatigue failures in this area are seldom eliminated by adding large masses of steel. Much more can be gained by eliminating the cause of the high loading, using a higher



(A) Keeper design of triple bead type and (B) improved design which grips the valve so that the bending loads are taken on the full diameter.

strength material, and lowering valve temperature.

Valve guide length and position have an effect on valve temperatures and motion. A guide length of not less than 50 per cent of the total valve length, evenly spaced, is a good rule of thumb. Most engines have guides longer than this. Lowest valve temperatures in the critical area beneath the head are obtained when the guide boss and cooling water jacket are brought close to the valve head. Port cross-sections may become unsymmetrical and casting difficulty experienced, but results are worth a good try.

A lock ring in a groove on the valve stem can prevent a valve falling into the combustion chamber if the valve spring breaks. Damage to the engine can still result, however, if valve to piston clearances are close. Bending loads, resulting from out-of-square springs or other causes, concentrate stresses in the lock ring groove and valve stem fatigue failures at this point may disappear with the elimination of the groove. After all, valve springs should also be designed so that they do not break.

On the other hand, the breakage then may be transferred to the valve keeper groove. Keeper designs of the double or triple bead type will concentrate these same bending loads in the first groove toward the guide. I cannot recall ever seeing a failure on one of these designs which occurred in the second or third groove. A design which grips the valve so that the bending loads are taken on the full diameter will greatly increase the life, or cause the failure to occur in some other place.

Another possibility is a design which allows the spring retainer washer to equalize the load by tilting on the valve stem. This precludes the use of wedge type keys which lock tight and instead introduces relative movement with its hazards of wear.

Valve Materials

Valve materials may be selected on the basis of (a) strength at the operating temperature, (b) hardness at the operating temperature, and (c) resistance to environment. The choosing of valve steels should not be considered as a mysterious activity, but is sometimes placed in this category due to the mystery surrounding the item of valve operating temperature. Testing to determine actual valve operating temperatures is not extremely difficult and values within 50 deg. F. are obtainable. I refer here to the property of hardness loss with temperature of certain steels. A valve steel such as silcrome No. 1 can be fully hardened to approximately 58 Rockwell 'C' and it will lose hardness when subjected to temperatures above 900 deg. F. The hardness will be in the neighborhood of 20 Rockwell 'C' when a temperature of 1550 deg. F. is reached, and in between these points a 100 deg. variation will change hardness about four points.

While this method may seem crude to exacting scientists, it is accurate enough to serve as a comparative test to determine the benefit of any design changes in lowering temperature. Surely if such changes will not show up in this test they cannot be expected to produce extended valve life.

Valve temperatures might be divided into zones and classed as cool, temperate, and hot. Cool meaning below 1200 deg. F., temperate being the range of 1200 deg.-1400 deg. F., and hot being above.

Classification makes the selection of valve steels, on the basis of hot strength or fatigue resistance, relatively simple. All of the commonly used valve steels have good strength in the cool zone, and none of them have good properties at temperatures above 1450 deg. F. The reason for sodium cooling any valve, gasoline or diesel, is to drop its temperature into the temperate zone or lower. Steels to operate in the cool zone are chosen with regard to ability to resist environment (corrosive or oxidizing atmosphere) and for economy. Inlet valves, and a few exhaust valves, are in this group.

Engine builders already know that austenitic steels have better strength properties than hardenable steels in the temperate zone. Proof is in the fact that the majority of diesel exhaust valves are made of austenitics. A common belief is that since these materials cannot be hardened by heat treatment then there is no point in heat treating. Hot strength, however, can be improved as illustrated in a comparison of creep tests on austentic steel alloys with and without heat treatment. The gain in creep resistance of several austenitic steels in the temperate zone is shown. While the tests charted are not on valve steels, the comparative improvement is evident by the increase in stress required for 0.1 per cent stretch in 1000 hr.

Austenitic valve steels show response

to heat treatment in similar manner, but a stepped up method of testing has been used to reduce test time without affecting results. The improvement of hot stretch resistance resulting from heat treatments applied to austenitic valve steels is illustrated. The validity of this test method has been checked by comparing engine valves of the materials shown with and without heat treatment. The use of nitrogen bearing 21-12 has reduced dishing and breakage and that is why it is being specified for many engines.

Hardness of austenitic steels cannot be increased to any marked degree with heat treatment, but it may be reduced by the same heat treatments that improve hot strength which indicates that a balance of desired properties must be sought.

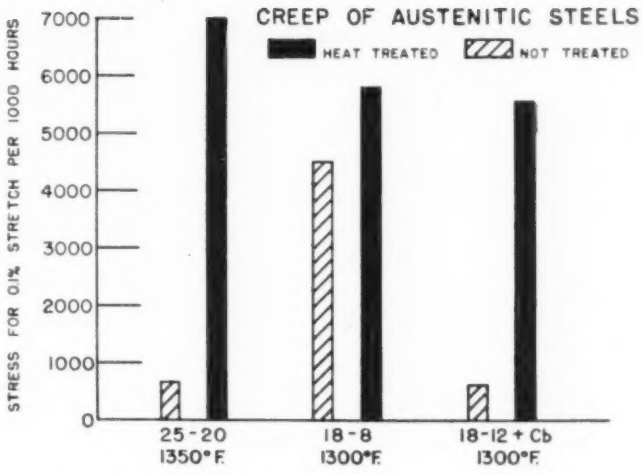
The severity of this test is too great for steels of the hardenable or semi-austenitic types, such as silcrome No. 1, silcrome x-be, or xcr, for these materials will stretch, dish or break in some engine operating conditions where the austenitics will not, thus further attesting to the validity of such a test. Reliable figures can be obtained with these materials if the stress is cut way down, or if they are run at a lower temperature.

A milder form of the problem of breakage, namely, lack of hot strength, may show up as dishing of the valve head rather than breakage. This dishing may result in loss of lash and subsequent valve seat leakage which raises the temperature. Proper choice of materials here is also essential.

One other point which might bear mention is that austenitic steels have lower coefficients of heat transfer and higher coefficients of expansion which must be considered in the engine design.

Seat Wear

The problem of seat wear in diesel engines has been present for many years with the greatest number of failures occurring on the inlet side. There are two possible explanations for this occurrence: one being that there may be different materials in the two ports because of the necessity of using a better steel on the exhaust for other reasons. This better material can either be a high alloy exhaust valve steel or some other corrosion resistant alloy such as stellite or eatonite which may also have a property of abrasion resistance better than the inlet valve.



The gain in creep resistance of austenitic steels in the 12-1400 deg. F. temperature zone with and without heat treatment.

The other possibility is that the exhaust valve is coated with deposits resulting from combustion which act as an insulating layer and prevent intimate contact between the exhaust valve face and the cylinder head seat.

The deposits seem to be most significant since it is a known fact that materials to be rubbed together without lubrication must be selected for this property. Most of the inlet wear, unless caused by dirt, occurs not on the valve but on the seat in the cylinder head and might be called fretting, scuffing, or microscopic welding. The rate of wear in some cases has been known to be as high as 0.001 in. per hour. Peculiarly, the wear may not occur on all valves in the cylinder head, and some cylinder heads may have an extreme amount of wear on one valve with none on another. This, apparently, is not a function then of metallurgical differences from one cylinder to another but is more an operating difference, such as the amount of relative distortion from one port to another and one cylinder head to another.

If distortion is found to be the cause, the use of other materials or a change in the cylinder head sections surrounding the valve might result in reduced wear. That this is true is evidenced by the fact that some manufacturers have eliminated wear by changing cylinder head structure, and others, unfortunately, have gotten into the wear problem by making such a change. Distortion creates wear by causing the valve to contact only a small portion of the cylinder seat when contact is first made at seating. The valve then either slides or is forced by cylinder pressure into full contact provided, of course, the seat is still round. This small movement at high pressure is the start of fretting or roughening of the valve or seat. It is aggravated by poor valve motion and bad mechanical conditions which allow misalignment. A change of seat angle may give relief: for example, if distortion is lateral, a 15 deg. seat angle valve would be unseated much less than a 45 deg. valve.

The use of a different material combination has to date been the most positive means of reducing wear. Its effectiveness has not been 100 per cent and what works in one engine may not work in another. The choice of materials is limited to cast iron for the seat, unless the manufacturer resorts to the use of a seat insert, and the valve materials. Considerable testing is involved in choosing the right combination and the medicine may be bitter from the standpoint of cost.

Some valves have shown reduced

wear of the valve face or cylinder seat face when allowed to rotate; others have shown more wear. Rotation should be noted in conjunction with this problem and, if beneficial, incorporated.

The use of coatings on the face of the valve or cylinder head seat remains to be exploited. I refer to such things as tinning which is done sometimes on other engine parts to eliminate scuffing.

Hardening of the cylinder head iron has shown benefits, but high valve hardness has not been very effective since the greater amount of wear is usually on the cylinder head, particularly if no insert is used. The direct application of stellite on the cylinder head is sometimes a salvage measure and often improves life.

Valve Face Guttering

Valve face guttering, on the other hand, has been primarily an exhaust valve problem. It might be considered as having two phases; one being the result of distortion which allows leakage to occur in one local area, or as a result of bad mechanical conditions; and the other phase being the leakage which results when deposits which have formed between the valve and seat break away. Gasoline engines have long been subjected to the formation of deposits but the problem is relatively new for diesel engines. What the future holds cannot be predicted, but indications are that lubricating oils containing high quantities of additives will increase the amount of deposit formation on diesel engine valves and thereby aggravate the problem of seat leakage. Additives in the fuel could further complicate the picture. Improving life under both of these conditions which cause leakage can be based on experience gained in improving life in gasoline engines.

A valve material selected for its resistance to environment is indicated. Hot hardness values for various steels which are an indication of resistance to pitting by indentation or deformation which may lead to guttering are shown. Temperatures of 950 deg. F. and 1300 deg. F. are used and the data from mutual indentation are given as Brinell hardness. In the temperate zone the hard facing alloys, stellite and eatonite, are most useful. The same chart rates the scaling resistance of these materials, but for simplicity these are shown in three groups; i.e., (a) carbon or low alloy steels whose loss in scaling is 20,000 milligrams/200 hr. or greater; (b) valve steels with loss range of 30-150 milligrams/200 hr.; and (c) stellite and eatonite with values less than 20 milligrams/200 hr. The relative scaling resistance of carbon steels or standard low alloys like SAE-3645 and the valve steels helps to explain why the low alloys are being replaced as inlet materials.

Experience on a few tests with high ash oils indicates that guttering on valves and seats of both inlet and exhaust can be caused when small areas of deposits break off. The guttering is straight high temperature oxidation and not corrosion. Diesel engineers use exhaust gas temperature as an indicator but do not realize that high-pressure, high-temperature leakage can create 1500 deg. valve temperatures without affecting exhaust gas temperature which might be as low as 800 deg. Thirty to 50 hr. of full output running (with a narrow leakage area) can cause bad guttering on valve steels, whereas upwards of 250 hr. are required with a hard facing under the same conditions.

Guttered valves, even when hard faced, are possible with present fuels and lubricants indicating that a close watch on temperatures is required. One valve returned to us for comment had a bright shiny appearance at the seat contact with a couple of guttered areas, but after electrolytic cleaning the gutters were no longer present. The steel showed practically no effect of the leakages and the deposit which formed the seating surface was entirely gone.

Here, again, rotation has proved of benefit in keeping temperatures, deposits, and leakage under control. The use of rotators in diesel engines is relatively new but the gains in valve life may well justify the expense of incorporating a device which will allow valve rotation.

Stem and Guide Wear

The problem of stem and guide wear is essentially no different than other problems of engine wear. It is a function of three things; (1) materials and hardnesses, (2) load, and (3) lubrication.

The use of special materials, heat treatments, coatings, etc. has shown some merit and several manufacturers are using valve guides which have been ferroxed or parco-lubrized with a degree of success. Size and surface finish are also important and proper valve train geometry must not be overlooked.

The most effective element in freedom from wear is adequate lubrication assuming that the aforementioned factors are given recognition. Past experience has indicated that nearly any material combination will be successful, since the loads are light, if given a reasonable amount of lubrication; but very few materials will operate satisfactorily in a dry state. The problem becomes one of maintaining satisfactory lubrication on both exhaust and inlet valves without over-lubricating the inlet valve, and thereby increasing oil consumption or under-lubricating exhaust valves as a result of scanty oil supply or deposits. The use of an oil seal ring on the inlet valves coupled with close stem to guide clearance may effectively satisfy the inlet valve requirement, and an ample oil supply on the exhaust with the minimum possible stem to guide clearance for effective control and improved heat transfer may be the most satisfactory. Excessive stem to guide clearances hamper the transfer of heat from the valve to the cooling medium and allow room for deposits to form which reduce the effectiveness of lubrication.

Sticking

The problem of sticking has been placed at the end of the list since it might be classed more as a nuisance problem on diesel engines. Sticking results from building up of deposits on the valve stem causing it to be sluggish in the guide or, in some cases, causing it to actually become wedged to the point of not operating. If the valve sticks in an open position it may be struck by the piston resulting in engine damage. At this point it is more than a nuisance.

The problem may be approached from two directions; first, do not provide any space for deposits to form, that is, keep stem and guide clearances

MATERIAL	HOT HARDNESS BRINELL		SCALING RESISTANCE Mg./200 hrs.	
	950°F.	1300°F.	OXIDIZING	REDUCING
CARBON OR LOW ALLOY	200	UNDER 40	ABOVE 20,000	
EXHAUST VALVE ALLOYS				
SIL-1	(250)	40		
X-Be	254	40	↑	↑
XCR	230	110	30	50
21-12	130-180	90-116	to	to
21-12+N_2	130-180	90-120	90	150
SIL-10	142	90	↓	↓
FACINGS				
STELLITE #6	(320)	(275)	LESS THAN 20	LESS THAN 15
EATONITE	(350)	(330)		

Table showing hot hardness value and scaling resistance for various steels. Hot hardness values are an indication of resistance to pitting by indentation or deformation and the relative scaling resistance helps to explain why the low alloys are being replaced as inlet materials.

to a minimum. Any spaces that are available for deposits to form should be as wide as possible so that these deposits can reach their maximum normal thickness without obstructing the movement of the valve. An example is the use of counterbores in the valve guide which, if used, should be large enough to allow the deposits to build up and break off before they will wedge.

It is better still to reduce the guide length so that the point of first contact between the valve and guide occurs where the temperature is low enough not to cause breakdown of the oil to form deposits.

The use of oils which have reduced deposit tendencies is recommended, but the most effective elimination of valve stem sticking is the use of a device which allows the valve to rotate.

The use of solvents on valve stems to remove gummy formations has been tried successfully by some engine builders. One had a passage leading through the valve guide and cylinder head to the outer deck next to the valve spring and periodically a solvent was forced into this passage. Subsequent use of a release type rotator showed such benefit that it was adopted in production.

Summary

In summary, then, the causes of breaking are:

(1) High loading of valve resulting from—
- (a) wear in valve train
- (b) overspeeding
- (c) high lash
- (d) cam design not matched to valve gear
- (e) maintenance, cocked springs out-of-round seats, etc.

(2) Valve weakness caused by—
- (a) design of valve structure
- (b) material inadequate at temperature

The causes of seat wear are:
- (1) incompatible materials
- (2) high unit loading
- (3) material inadequate at temperature

The causes of valve face guttering are:
- (1) leakage resulting from out-of-roundness
- (2) leakage resulting from deposits breaking away
- (3) materials which will not withstand environment (temperature, atmosphere, indentation)

The causes of stem and guide wear are:
- (1) poor geometry
- (2) wrong materials, finishes, etc.
- (3) poor lubrication

Sticking is caused by stem and guide deposits resulting from:
- (1) too high a temperature for the oil
- (2) scanty oil supply
- (3) excessive stem to guide clearance

The remedy for these problems lies in recognizing which causes apply in each case and using all available knowledge to eliminate them.

Pilot Injection for High Speed Diesels

Pilot injection, in this case, is not to be confused with the term as applied to gas-diesels and dual-fuel engines. Perhaps 'Two-Stage Injection' would be more descriptive. Systems of this type have received considerable attention, particularly in Europe, and are exemplified by the Atlas-Polar system for the larger slower speed engines and now this development of C.A.V. Limited for application to the higher speed engines.

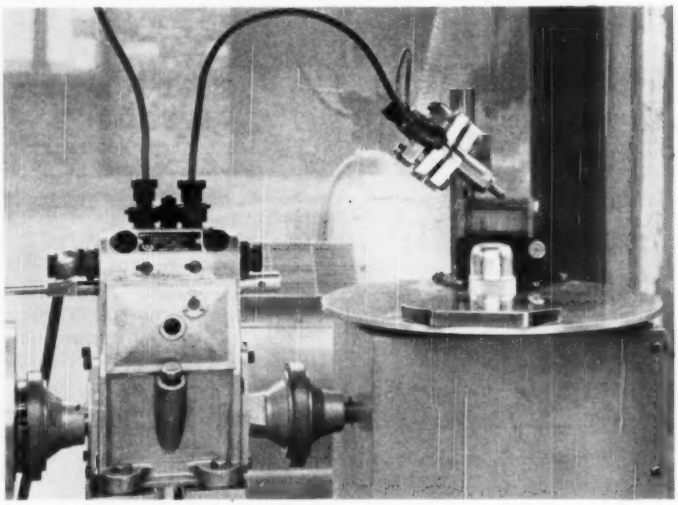
FUEL injected into the combustion chamber of a diesel does not commence to burn immediately, although the temperature of the air charge may be ample for ignition. There is a short, but quite definite and measurable interval of time, known as the delay period, during which the fuel must be heated to its spontaneous ignition temperature. This temperature varies, of course, according to the quality of the fuel and especially its cetane number. The delay period, or time lag, will depend further on the degree of fuel "atomization" achieved and on the rate of transfer of heat from the compressed air charge to the fuel. The latter factor will in turn depend on air density and movement within the chamber.

The influence of the delay period on the combustion of fuel in the compression ignition engine is well known. In particular, it is the cause of the uncontrolled burning of the first part of the fuel injected into the combustion chamber, giving rise to an excessively rapid pressure rise and the consequent characteristic sharp noise known as "diesel knock".

The rapidity of the pressure rise when active combustion begins at the end of the delay period depends largely upon the amount of fuel which has been injected during that time. It follows that if the delay period can be shortened, or alternatively if the rate of fuel injection can be reduced during the delay period, the ensuing rate of pressure rise will be reduced, with benefit both in reduced engine noise and shock loading on running gear.

The first alterative, the shortening of the delay period, requires in a given engine an improvement in the ignition quality of the fuel, that is, an increase in the cetane number. Unfortunately, as some of the leading authorities on oil production have pointed out, the future economics of crude oil refining are more likely to lead to a reduction in the cetane number of available diesel fuels, than to an increase.

The second alternative, the reduction of the initial rate of fuel delivery, commonly called "pilot injection", has long been known to be effective in improving the control over combustion, and many designs of fuel injection equipment have been patented which claim to achieve this result. Until recently, none of them have been sufficiently practical or suitable for adoption with high speed engines such as are used for road transport, and many marine and industrial applications.



Fuel delivery rate analyzer developed by C.A.V. and used in the study of pilot injection. Each cell in pack on turntable represents ¾ deg. of camshaft rotation as turntable is synchronized with injection pump.

Interest in the possibilities of such a system has been stimulated both by the warnings of eventual deterioration in the ignition quality of fuel and by a growing desire amongst operators and the public for quieter engines. Information published by the Thornton Research Laboratories (in Great Britain) of the Shell Company some time ago demonstrated the advantages to be gained by pilot injection on a bus engine, but pointed out the lack of practicable equipment for this purpose.

It will be appreciated that one way of reducing the initial rate of fuel injection is to reduce the rate throughout the injection period. This however would lead inevitably to a serious loss in combustion efficiency and rise in fuel consumption, which of course could not be tolerated.

There are two methods of achieving the low initial rate of fuel delivery without impairing the efficiency of the combustion cycle. The first, of which the Shell Company's tests are an example, is to inject a small quantity of fuel ahead of the main charge. This "pilot" charge commences to burn after the lapse of the delay period, but the quantity is so small that the amount of uncontrolled pressure rise is much less than normal. The main charge is timed to inject just as this combustion of the pilot charge com-

mences, and as flame has already been propagated, it is not subjected to any appreciable delay and burns smoothly under the control of the chosen rate of injection. This rate is designed to be high enough to enable combustion to be completed sufficiently quickly for the maximum cycle efficiency.

The second method avoids the mechanical complications of the distinct break in the injection involved in the first. It provides a continuous injection, the first part at a low rate lasting for the delay period, followed without interruption by the second part, at a higher rate. Thus the quantity of fuel injected during the delay period is kept at a minimum, while the remainder, and the majority of the fuel, is injected at a high rate to complete combustion as rapidly as possible, but still under control, and again retaining full cycle efficiency.

The latter method has been successfully achieved by the system described in the following and now being applied to high speed passenger transport engines by C.A.V. Limited. Much development work has been followed by extended tests of the equipment under actual operating conditions and these have indicated that a very distinct improvement in quietness and smoothness of running vehicles can be achieved.

The characteristic diesel knock and usually combustion noise of these engines has been practically eliminated. The improvement is most marked when idling and during acceleration, and is obtained without any sacrifice in fuel consumption.

The special features of the equipment consist of a specially developed injection pump, cam profile, pump delivery valve, and injector.

Two-stage Cam

The desired rate of injection characteristic is obtained by a two-stage cam and gives a plunger displacement curve of the form shown in Fig. 1. The pumping plunger is of the C.A.V. port-controlled type with helical spill edge providing for termination of injection according to load. Pumping commences when the cam follower approaches the top of the first stage of the profile and proceeds at low velocity over the nose on to the second stage of the cam. This phase is shown by (A) on the displacement diagram. It will be noticed that the follower is always rising during this phase, although at low velocity, so that there is no interruption in pumping. Upon reaching the flank of the second stage of the cam, the follower is lifted abruptly and pumping continues at a much increased rate, until the injection is terminated in the usual manner, when the spill port is uncovered by the helical edge of the plunger. This phase is shown by (B) on the displacement diagram.

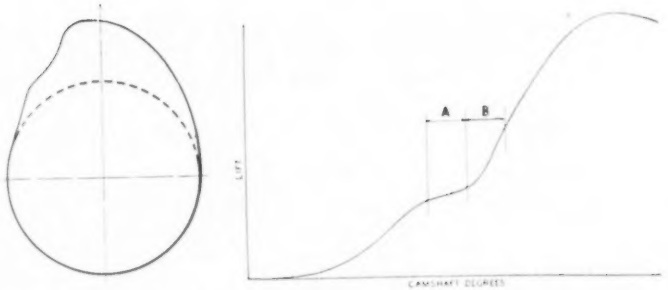
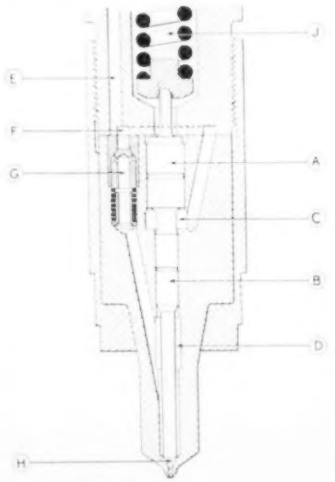


Fig. 1—Typical pilot injection cam profile at left with the resultant pump plunger displacement diagram at right.

Nozzle Design

It is found that the low initial pumping rate thus achieved does not result in a corresponding low rate of fuel injection from the nozzle unless the latter is arranged to open at a much lower pressure than that normally employed. The reason for this can be seen when it is realized that compression of the fuel in the delivery line must take place before a pressure sufficient to open the nozzle is obtained, and the energy thus stored produces a sudden release of fuel from the nozzle when it eventually opens, so defeating the desired object. Unfortunately, if the usual differential valve nozzle is adjusted to open at a fuel pressure sufficiently low for control of injection to be maintained, the pressure at which it closes on termination of injection is even lower, and will be less than the gas pressure in the engine cylinder. This would result in the nozzle valve being held open by the gas pressure until this had fallen during expansion, and hot gases would enter the nozzle, causing fouling of the injection holes and other interior parts by carbon. Such a condition known to cause very rapid deterioration in nozzle performance, and must be absolutely avoided.

Fig. 2—Sectional view of the injection nozzle.



The objection is overcome by the special type of nozzle shown in Fig 2. The nozzle needle has two lapped guide portions (A) and (B), forming with the nozzle body two separate spaces (C) and (D) in which fuel pressure can operate. The upper space (C) is in direct communication with fuel feed passage (E) via the annular groove (F) in the lower face of the nozzle holder body, while the lower space (D) communicates with the same feed passage via a small check-valve (G). The lower space also communicates via the main nozzle valve seat (H) to the injection holes in the usual manner. The valve is held down by spring (J).

The operation of the nozzle will be best appreciated by considering the opening and closing phases separately. When pressure rises in the feed passage (E) at the beginning of injection, it operates equally in both spaces (C) and (D), since the check valve offers only negligible resistance to flow of fuel in this direction. Thus the effective area of the needle valve exposed to fuel pressure during the opening phase is equal to the difference between the area of the large guide diameter (A) and the valve seat (H); the small guide diameter (B) plays no part during opening. The compression of the spring (J) is adjusted to give the required opening pressure, usually 70 atmospheres, and is equal to the product of this pressure and the effective area referred to above.

When the nozzle valve has lifted, the effective area operated upon by fuel pressure is increased by the area of the valve seat (H). It is this increase in effective area which in the normal simple differential valve nozzle causes the closing pressure to be lower than the opening pressure, since the product (fuel pressure x effective area) must always equal the spring load, which is substantially constant for the small valve lifts employed.

During the closing phase, the special features of the pilot injection nozzle come into effect. Consequent upon the uncovering of the spill port of the pump by the helical edge of the plunger, fuel pressure in the line and passage (E) begins to fall, and with it that in the upper space (C) with which the feed passage is in direct communication. This fall in pressure in the upper space causes the nozzle valve to commence to close under the influence of the spring force. No corresponding fall in pressure can take place in the lower space (D) however, since flow of fuel back to the feed passage is arrested by closure of the check valve (G). Fuel from this space thus continues to be expelled from the nozzle holes, at a pressure determined by the downward displacement of the needle valve under the influence of the spring. The final closing of the nozzle somewhat resembles that obtained with a spring injection system, and pressure at the nozzle holes is maintained higher than the cylinder gas pressure until the final closure is made by the seating of the main nozzle valve.

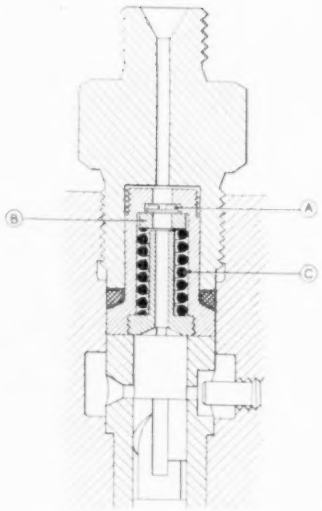


Fig. 3. Arrangement of pump delivery valve.

Delivery Valve

The pump delivery valve is the third special feature of the system and is also associated with the low opening pressure of the nozzle.

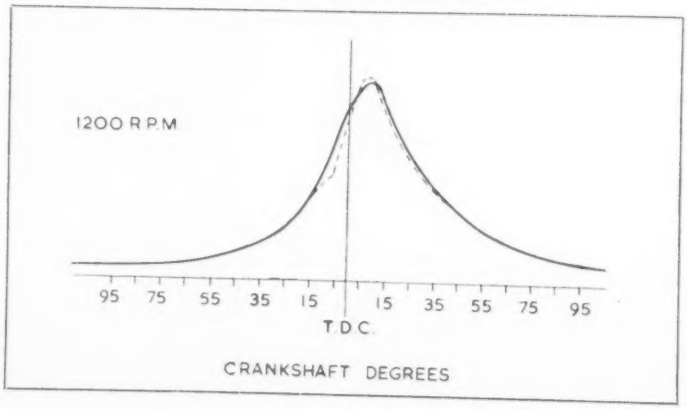
The usual type of pump delivery valve, although provided with a retracting piston to avoid undesirable residual pressures in the fuel line, cannot re-open once it has shut on the termination of injection, before the next pumping cycle. Hence the pressure wave set up at the nozzle by the closure of its valve becomes almost completely reflected at the closed delivery valve, and travels forward again to the nozzle. This may have sufficient intensity to re-open the nozzle, particularly if it is set at a low opening pressure as in the present case.

Complete reflection of pressure waves at the delivery valve is avoided by the special construction of the valve designed for use with pilot injection equipment, shown in Fig. 3. During the forward flow of fuel from the pump to the nozzle, the valve offers little resistance, since the small disc valve (A) is free to lift off its seat. When the pump pressure falls at the end of injection reverse flow causes the valve (A) to reseat, but unloading of the line proceeds by opening of the larger annular valve (B) downwards against the spring (C).

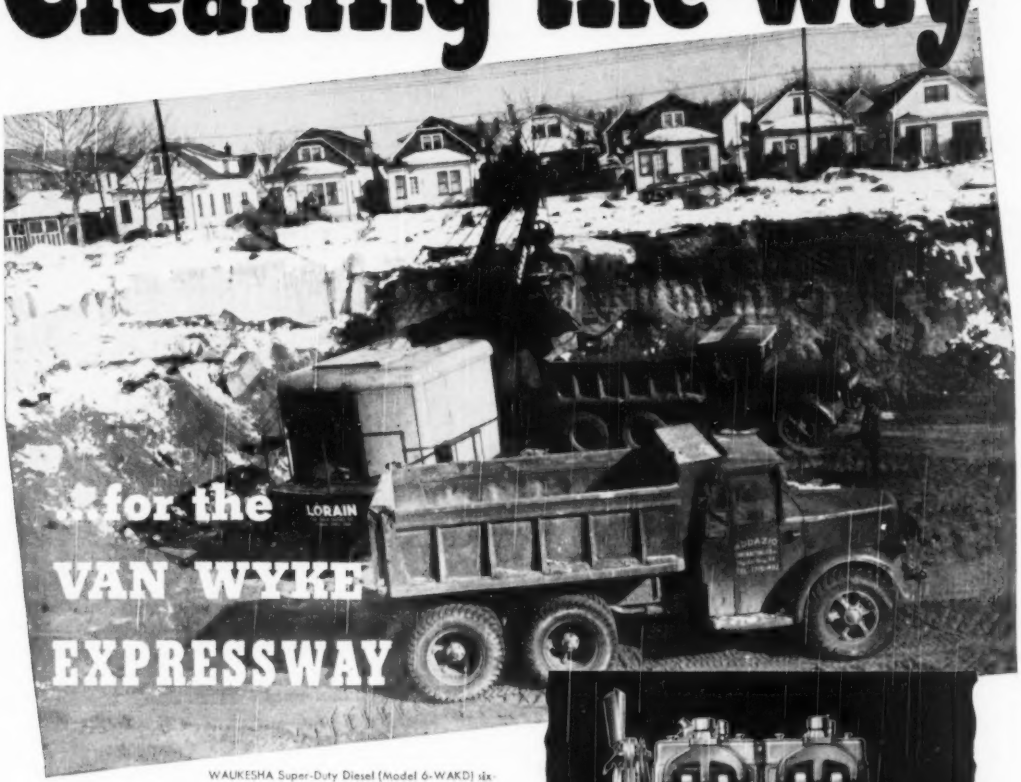
This valve will remain open until line pressure has fallen to the pressure determined by the spring loading. Pressure waves arriving at the delivery valve will therefore not be completely reflected even if this return flow valve has temporarily shut, and so the intensity of the return pressure waves arriving at the nozzle will be considerably reduced, and will not be sufficient to re-open the nozzle.

Fuel line pressure diagrams taken near the nozzle show remarkable freedom from the usual succession of pressure fluctuations following the termination of injection.

Fig. 4. Typical cylinder pressure curves. Solid line represents pilot injection curve with superimposed curve (dotted) for same engine with conventional system.



Clearing the way



WAUKESHA Super-Duty Diesel (Model 6-WAKD) six-cylinder, 6¼" bore x 6½" stroke, 1197 cu. in. displ.

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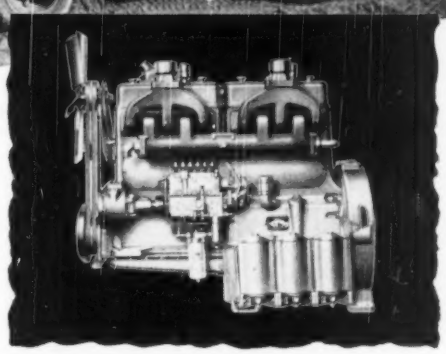

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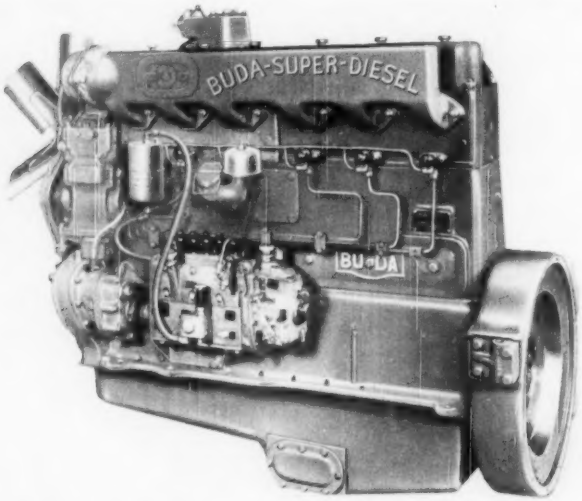


New Buda Truck Engines

The Buda Company recently announced the development of three new 161 Series, heavy-duty diesel truck engines — model 6 DAS-344, a supercharged 230-hp. unit; model 6 DA-344, a 215-hp. unit; and model 6 DA-779, a 135-hp. engine. All have six cylinders with practically the same mounting dimensions and are built on the same production line. Designated "Dyna-Diesel" engines, the last three figures of the model numbers indicate their displacement. All have a bore of $5\frac{1}{4}$ in. with a stroke of $6\frac{1}{2}$ in. for the larger units and a 6-in. stroke for the smaller.

The features claimed are more power with less weight, lower fuel consumption, more mileage between overhauls, less maintenance on the road, no smoke and smoother operation. These engines have a new special mono-lobe "Dyna-Swirl" combustion chamber enabling them to develop increased horsepower. The Buda controled turbulence, low pressure combustion system is designed to provide thorough utilization of the fuels so that there is no wasted fuel in the form of smoke. Low, more uniform cylinder pressure makes for smoother performance with less wear of moving parts.

Crankshafts are completely counterbalanced and engines are provided with torsional vibration dampeners to insure smoother engine operation. A large number of the engine parts such as intake manifolds, compressor brackets, oil cooler housing, gear housing and covers, etc. are made of aluminum to reduce the total engine weight.

Electric Oil Pre-Heater

A new multi-pass type of electric oil pre-heater, announced by the Hynes Division of the Martin-Quaid Co. is said to eliminate the problem of carbonization of the heating surfaces and provides fuel of more uniform viscosity for combustion.

The multi-pass oil heater has flat tubular heating surfaces staggered so that the oil passes back and forth through a positive channel in a thin, turbulent stream and at high velocity. Throughout the channel there are no dead spots so that all the fuel is uniformly heated. The large, low watt density heating surface and velocity flow virtually eliminate carbonization and sedimentation thus reducing maintenance and the possibility of damage to the heater. Heating elements can be readily removed from the multi-pass heater without draining the oil.

Self-Positioning Gage

Said to be easily used by unskilled labor for quality control inspection during production, the new self-positioning Nilco Dial Groove Gage is designed to accurately measure internal groove diameters and recesses used for precision retaining rings of the Truarc type, ordinary snap rings, O-rings, oil and washer grooves, etc.

The nose of the gage has two extensions. The upper extension has a gaging pin, set between two prongs of the patented one-piece plunger. The two prongs, having a 60 deg. chamfer and a flat edge slightly less than groove width, center the pin in the groove and position the axis of the pin through the exact center of the bore. The lower extension—with fixed gaging insert—is pulled in by a trigger, when inserting the nose into a housing. Releasing the trigger locates the groove almost instantly. The dial indicator—in 0.0001, 0.00025, or 0.0005 mm. calibrations—gives quick, accurate reading.

Each size gage can be set by a simple vernier within a wide range of diameters. Changing the setting does not change the spring tension on the gaging pin. The setting can be made with gage block combinations, micrometers, or master ring gages.

Fuel Pump

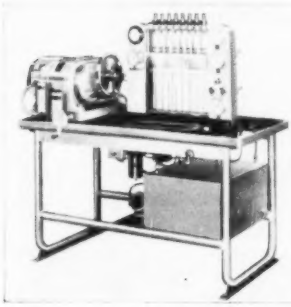
A new fuel pump said to be 65 per cent lighter in weight and 56 per cent smaller in size than the type it replaces has been announced by Cummins Engine Company. The new DD (double-disc) pump is now offered as standard equipment on the 300 hp. model NHRS-600 and 275 hp. model NHS-600 Cummins diesels and is also available as optional equipment on other model engines. A tandem arrangement of the new pump is standard on the 12-cylinder 400 hp. model

NVH-1200 and 550 hp. model NVHS-1200 Cummins engines.

Design of the DD pump enables unit replacement of the fuel pressure pumps, distributor discs, and governor assembly without removal of the pump from the engine. Alignment in the servicing of the pump is minimized since all parts and the bearings in which they rotate are included in the same housing.

Injection Pump Test Stand

A new test stand for diesel fuel injection pumps has recently been introduced by Automotive Products, Inc. Designated the AP 3200 calibrating stand, the new piece of testing equipment is a self-contained unit for cali-



brating, testing and adjusting fuel pumps. With adapters, nearly every type pump can be tested and calibrated, the manufacturer says. Pumps and governors can be completely set to exact factory specifications.

Flexible Coupling

Two new couplings designed for use on motor-driven and engine-driven pumps, compressors, generators, pulverizers, and almost all machinery of 50 to 1000 hp., have been introduced by the Lovejoy Flexible Coupling Co. The firm says that extra ease of installation and larger bore capacities are important features of the Type "C" and "H" couplings.

In these new couplings, the inside sleeve is made in two parts, instead of one—providing a sleeve for each body. Both bodies are machined alike for the removable steel collar. The collar, which can be put on either half of the coupling, is held in place by a snap-ring.

New Dynamometers

A new addition to their line of dynamometers—30, 40, and 50,000 lb. capacity traction type dynamometers—has been announced by W. C. Dillon & Co., Inc. The firm has long specialized in the manufacture of low capacity dynamometers from 0-500 lbs. and up to 0-20,000 lbs. The new higher capacity instruments are expected to fill the gap where huge loads are encountered.

The instruments are used for checking draw-bar pull, weight of bulky objects, tension in ropes and cables, static loads, etc. Large items that must be tested cannot fit into an ordinary laboratory tester and can only be handled by means of a dynamometer. The dial diameter of the new units is 10 in. compared to 5½ in. for the firm's present line. The instruments can be used indoors or outdoors wherever the job may be.

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Murphy Expands Line

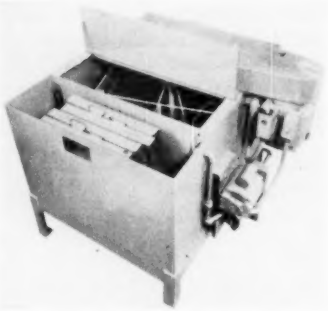
The Murphy Diesel Company has recently announced certain refinements in design which are claimed to provide more power, greater economy, greater dependability and longer life. At the same time the number of models has been increased. Five 4 cylinder models and six 6 cylinder models ranging in output from 90 to 200 hp. are now available.

The Murphy principles of "true" diesel operation, plain open combustion chamber, four valves per cylinder, hydraulic servo-type governor, etc. remain as the basis of the design of the engines, the additional power output resulting from improvements in the application of these principles.

Air Filter Cleaner

A new utility washing and oiling machine for servicing viscous, impingement, panel-type air filters has just been announced by the Farr Company. The new washer and oiler is a modified version of previous models with a considerably lower cost.

It is claimed that use of the washer and oiler reduces air filter maintenance costs as much as 67 per cent, substantially increases filter life, assures positive oiling, and permits lower inventory stock. The unit can be operated by one inexperienced man because all controls are automatic. The *Far-Air* Utility Filter Washer and Oiler accommodates filters up to 20 in. x 28 in. x 4 in. in size.



Parts Cleaner

A whirlpool action parts cleaner developed by the J. P. Manufacturing Co. for degreasing, washing and cleaning has recently been placed on the market. The manufacturer says it will remove grease, sludge, varnish, gum, paint, rust, carbon and other accumulated dirt deposits in one operation.

In operation a propeller drives all the solution at a rate of speed between 50 and 60 mph. to build up tremendous pressure against all external and internal surfaces of the materials to be dissolved and forcibly removed. The cleaner traps all dirt deposits into a drawer in a lower compartment through a hole in the center of the cleaner. The sediment pan in this drawer can be removed and cleaned while the solution remains in the tank.

The cleaners can be supplied with gas, steam or electric heaters which work automatically at any temperature and are available in sizes from 35 to 1,000 or more gallon capacity. The flue pipe for the burners is built into the tank completely and acts as an additional heater for the solution that surrounds it. The flue pipe can be used as a crane assembly, permitting the crane to perform a circle without additional attachments.

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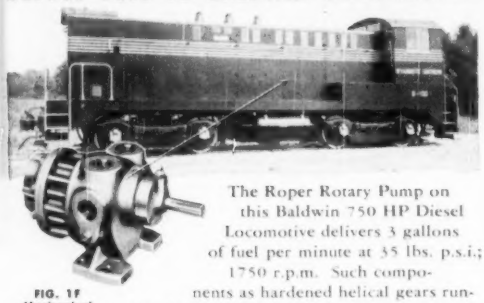

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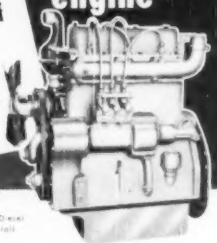

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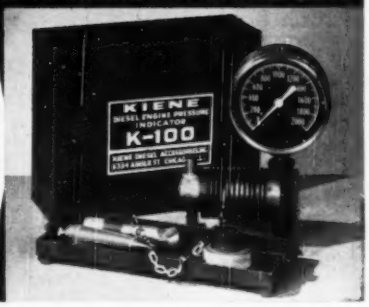

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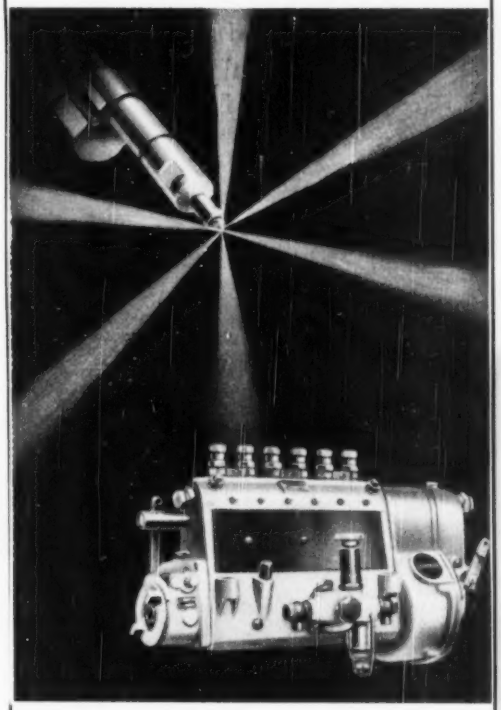

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Established 1907

Representatives in Boston • Cincinnati • Detroit • Houston • La Junta, Colo. • Los Angeles Minneapolis • New Orleans • New York • Philadelphia • Portland, Ore. • San Francisco Seattle • St. Louis • Tulsa • Representatives in Canada: Montreal • Toronto • Vancouver

Vapor-Spray Degreaser

The design of a new, large capacity vapor-spray degreaser has just been announced by Circo Products Company. This new model, called the C-120, was designed for the transportation field and heavy industrial use. It has a vapor depth of 34 in., inside length of 96 in. and width of 60 in.

The degreaser is available in either nickel clad, stainless clad or zinc sprayed construction. Its nonflammable, non-explosive solvent is heated by steam, gas or electricity, forming a blanket of vapor which is 34 in. deep. Ample heat input assures a cleaning capacity of 13,000 lbs. per hour. An outside water jacket and inside water coils give double protection against vapor loss. Safe, economical operation is assured by a fully automatic control system.

Removable Bundle Exchanger

A new line of standardized exchangers, featuring all-cuprous, removable tube bundle construction, is now in quantity production by Ross Heater & Mfg. Co.

Designated Type BCP, the line is available in a broad range of sizes which not only compare favorably in cost with many iron and steel shell units, but actually cost less in the smaller sizes.

Originally designed for service on Navy combat vessels, the Type BCP has just been extensively redesigned. It has been adapted to low-cost, quantity production and now embodies larger transfer surface. A smaller, less expensive unit now serves the same conditions that formerly required larger, costlier sizes.

SPECIFY Reiner ESTABLISHED 1927 ...FOR AROUND-THE-CLOCK DEPENDABILITY

100 KW Reiner Diesel-Generator installed in a large New Jersey department store for stand-by duty. Time and again, its instant, automatic starting has insured uninterrupted light and elevator service when outside power failed.

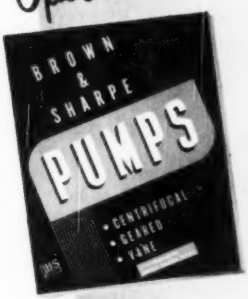
- Reiner generating sets come in a wide range of sizes and types for every power need.
- They're designed for utmost economy, efficiency and dependability in operation.
- Reiner's 25 years' experience and worldwide reputation for quality materials and expert workmanship assures you of the very latest in technical design and engineering.

JOHN Reiner & COMPANY ESTABLISHED 1927

FREE BULLETINS on standard units sent on request. Write today, stating your requirements.

DEPT. 41, 12-12 37TH AVENUE
LONG ISLAND CITY 1, N. Y.
Cable Address: REINERINC

For Trouble-free Diesel Operation...



Send for a copy of this Catalog and see how many quality-built Brown & Sharpe Pumps are available for diesel use. A wide range of types and sizes in standard rotary geared pumps with various styles of special mountings greatly simplifies the right selection for the job. Have a catalog handy for quick reference. Brown & Sharpe Mfg. Co., Providence 1, R. I., U. S. A.

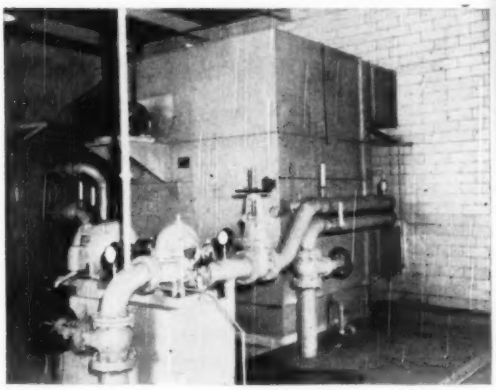
WIDE SELECTION PERMITS THE RIGHT CHOICE

We urge buying through the Distributor

BROWN & SHARPE BS

WRITE FOR THIS BULLETIN On These Efficient Compact Closed-System Coolers

Yes it's CLEAN cooling of Diesel Jacket water because it's "closed-system" cooling with "Buffalo" Evaporative Coolers! Keeps foreign matter out of jacket water. And "Buffalo" spray-on-coils cooling is economical on water, fan and pump power. Space-saving 3-section design simplifies installation — indoors or out. WRITE TODAY for Bulletin 3666 — see why "Buffalo" is the choice wherever Diesels are to be positively and dependably cooled!



BUFFALO FORGE COMPANY

140 MORTIMER STREET BUFFALO, NEW YORK
Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

Branch Offices in All Principal Cities

EVAPORATIVE COOLERS AND AXIAL FLOW FANS FOR COOLING MOBILE AND STATIONARY DIESELS

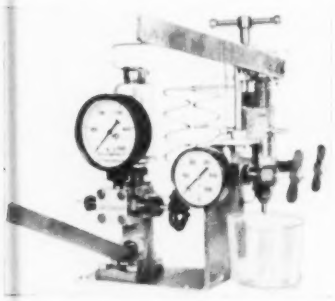
Nozzle Tester

Bacharach Industrial Instrument Company is now manufacturing a fixture for use with the Bacharach Nozzle Tester which provides a self-contained, complete testing device for General Motors Series 71 injectors and unit injectors of the Gray Marine Model 64-HN9 engine.

The fixture comprises a stand and clamping apparatus, complete with a 2,000 lb. gauge, valves and necessary fuel lines. It is mounted on the base of the stand by means of three bolts.

This unit is suitable for all recommended tests on GM71 injectors including checking spray pattern and nozzle opening or "pop" pressure; determining pressure drop in the injector; checking for leaks at body seal ring, fuel rack, fuel line connections, etc.

An additional feature of this device is that it may be used for testing other nozzles such as Bosch, Bendix, and Demco makes without taking the tester off the stand. It is necessary only to disconnect the fuel line of the GM71



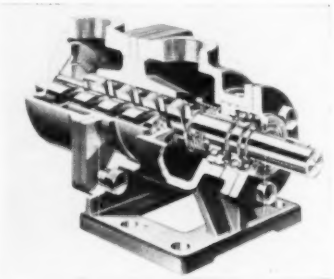
fixture, then make the connection to the nozzle to be tested by means of connecting tube and dual-thread nuts which are also made by Bacharach.

New Imo Pump

The new De Laval—IMO Series A313A pump is designed for pumping petroleum products and other light or viscous fluids in volumes to 35 gpm. against pressures up to 150 psi., as required for rotary and steam atomizing oil burners, oil transfer, lubrication, hydraulic systems and similar service.

This new pump has been designed especially for economical, standardized quantity production. Its reduced cost extends distinct advantages of the IMO principle to a great variety of applications requiring a reliable, quiet, pulsation-free, trouble-free, high speed pump.

Like all other IMO pumps, the A313A is extremely simple. There are only three working parts—a power rotor and a pair of sealing or idler rotors



which mesh with the power rotor in such a manner that liquid is conveyed continuously from inlet to outlet. There's nothing to get out of order or require adjustment. This De Laval—IMO can be direct-connected to electric motors, turbines or other high speed drivers without reduction gearing, belts or chains.

Because of its compact design, the De Laval—IMO A313A requires little space, and the fact that it can be direct-connected to its driver also is a space-saving feature. All parts are interchangeable. The mechanical seal requires no attention. The pump can be mounted in any desired position. Suction can be located at top, bottom, horizontal left or horizontal right.

New Literature

Air Filter Manual

The American Air Filter Co., Inc. has published a manual (130-E) covering new designs and improvements in their *Cycoil Oil Bath* air and gas cleaners. New sizes have been added to the WO1 air cleaner series and a new design (WO3) has been introduced. The WO3, identical with the Model WO1 except for the intake which is tangential instead of peripheral, permits control of the air intake or the addition of an extension for use with an intake unloading compressor.

Both the UO4 (low pressure) and the UO7 (high pressure) gas cleaners have been re-designed for wider ranges of working pressures. Selection charts, dimension tables and detailed engineering data are included.

Nordberg Engine Bulletin

The Type TS and TSM29 diesel engine described in newly published Bulletin 173 is typical of the contribution Nordberg Manufacturing Co. has made to the diesel power field. This engine is the most powerful, single acting, two-cycle diesel engine ever built in this country. It has a 29 in. bore and 40 in. stroke and is available in a size range from 5 to 12 cylinders with ratings from 3570 to 8500 hp. at normal speed of 164 rpm. for both stationary and marine service.

Bulletin 173 gives a general description of the design of the engine, low-cost fuel requirements, scavenging system, lubrication and piston cooling system and reversing gear arrangement of the marine Type TSM29 diesel engine.

Blackmer Bulletin

A new 6-page, 2-color bulletin, "Facts", by Blackmer Pump Company illustrates design, construction, maintenance, operation and application of rotary pumps. Details of sliding vanes and swinging vanes with selection tables for specifying and other data of interest to engineers, maintenance men and plant operators are included. Copies are available on request.

Bacharach Leaflet

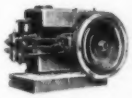
Bacharach Industrial Instrument Company has recently released a leaflet which describes their Chronomatic Engine Indicator for high speed diesel engines. The bulletin is freely illustrated with diagrams and photographs and gives a complete description of this instrument said to be the only engine indicator available today for recording a complete pressure-time diagram in a single engine cycle. The leaflet discusses the indicator connection, chronomatic drum, and pistons and springs.

SURE CURE FOR PUMP HEADACHES

Forget pump worries. Tuthill small pumps are recognized the world over for their dependability in lubrication, coolant, hydraulic and liquid transfer service. These internal-gear type rotary pumps are available in capacities up to 200 g.p.m. and pressures up to 400 p.s.i. Wide choice of porting and mounting arrangements in both packed and mechanically sealed pumps. Write for General Catalog.

TUTHILL PUMP COMPANY
939 East 95th Street, Chicago 19, Illinois

SENDLING



DIESEL-ENGINES
5 - 20 HP

Approved in all parts of the world

Horizontal Engines
Vertical Engines
Diesel Tractors 15 HP

MOTORENFABRIK MÜNCHEN-SENDLING
München 25 (Germany)
Established in 1899

Book Reviews

Kent's Mechanical Engineers' Handbook—Carmichael, C. and Salisbury, J. K., editors. Two volumes app. 3000 pp. John Wiley & Sons, Inc. publishers, $8.50 per volume.

The twelfth edition of Kent's Mechanical Engineers' Handbook has recently been published in two volumes, "Power" edited by J. K. Salisbury, Division Engineer, Thermal Power Systems Division, General Electric Company, and "Design and Production" edited by Colin Carmichael, editor of Machine Design.

The two volumes have been completely rewritten by the various contributors. The twelfth edition had 168 specialists contributing to it as compared to the 75 contributors to the outgoing edition.

In the preface to "Design and Production", Mr. Carmichael has written:

"This volume is directed primarily toward the engineers who design and manufacture machinery, appliances, mechanical equipment, and other engineered products. The twenty-eight sections into which the book has been rearranged may be classified broadly as: Selection of Materials (Sections 1 to 6); Design Principles (Sections 7 to 9); Design and Selection of Machine Components (Sections 10 to 18); Production Processes (Sections 19 to 25); Production Plant Equipment (Sections 26 and 27); and Mathematical Tables (Section 28).

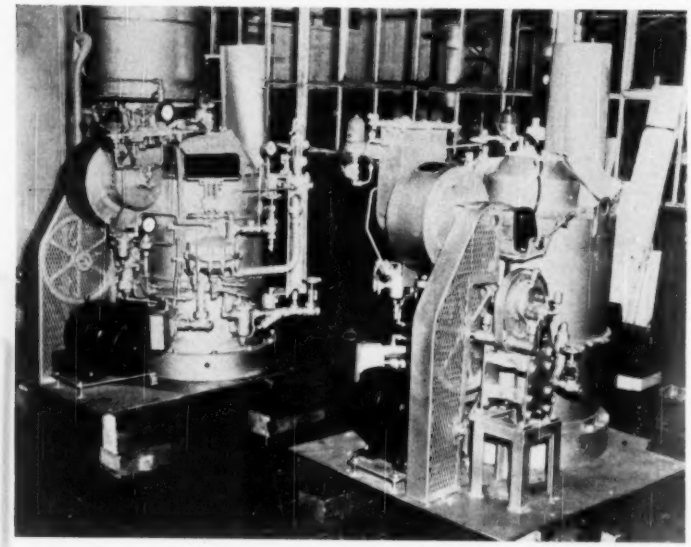
The presentation of each subject attempts to give the engineer a quick grasp of the essentials of the field, together with pertinent technical data in condensed form. These data consist essentially of: basic principles; working formulas, charts, and tables; standard dimensions, proportions, and specifications and illustrated discussions of typical equipment. References included in the text and at the ends of many of the chapters guide the reader to sources of more detailed information."

Mr. Salisbury, in the preface to "Power" has said:

"The broad purpose of the Power Volume is to cover the entire field of heat-power engineering and transportation, as well as the important aspects of fluid flow. Engineers concerned with materials, processes, and the mechanical design and fabrication of equipment will find this branch of mechanical engineering in the Design and Production Volume of the Handbook.

"This volume has been organized in groups of sections. The basic ingredients of any power process (air, fuel, heat, and steam) are covered in the first four sections. The service functions, pumping and piping, are covered in Sections 5 and 6. Power-producing equipment (boilers, turbines, condensers, and gas turbines) are covered in Sections 7, 8, 9, and 10. Sections 11 and 12 are devoted to refrigeration, heating, ventilating, and air conditioning. Transportation (diesel engines, land, air, and marine transportation) is covered in Sections 13, 14, and 15. Electric power, the end product of power machinery, is the subject of Section 16. Atomic energy, instrumentation, power test codes, and mathematical tables are the subjects of the last four sections of the book.

Field Notes



Steam for North African Railcars

We don't often think about heating trains in Africa but it gets chilly in the evenings and when up in the mountains, sometimes making it necessary.

Vapor Heating Corporation, Chicago, made the steam generators illustrated and some of the type on the right are now enroute to Africa to be installed in new 3-car streamline diesel trains. There is a diesel engine, steam generator, seating area and a cab in each end car, so the train can go in either direction, with traction at both ends.

These compact steam generators make 500 lb. of steam per hour using diesel oil for fuel. Once started, automatic controls take over and turn the machines on and off automatically to produce steam only when needed. Special name plates and instruction books in French were made up for these units, with dimensions in the metric system.

In the background on the left is a larger Vapor steam generator, the type used in diesel locomotives in this country, this machine has a capacity of almost 5000 lb. of steam per hour or ten times the output of the smaller units.

Ideal Buy

J. Walter Becker, president of Ideal Industries, Inc., has announced the purchase by his company of the entire business and assets of Tincher Products Company, Chicago manufacturer of the Tincher Process for sealing porosity in castings. The company will continue to operate under the name Tincher Products Company, but as a wholly-owned subsidiary of Ideal Industries, Inc.

G-M Award

Achieving the best safety record in its history, General Motors has been granted the National Safety Council's award of honor for distinguished service to safety.

The accident prevention record of GM employes during the past year was substantially improved over its previous best year from the standpoint of both the number of accidents and their seriousness. It was the sixth time that General Motors has been given an award in this category.

Ned H. Dearborn, president of the council, commended the GM achievement at a luncheon in Detroit, where he presented the award to Harlow H. Curtice, executive vice president of General Motors.

New Bendix Plant

Construction of a new plant on the West Coast has been announced by Bendix-Westinghouse Automotive Air Brake Co. The modern new building, located at 2000 Fifth Street, Berkeley, California, contains approximately 20,000 square ft. of floor space for sales and service and warehousing of new parts, as well as production equipment for rebuilding air brake units under the company's long established Repair Exchange Program.

Experienced sales and service personnel have been assigned to the plant. C. R. Mitchell, for many years Regional Manager at Philadelphia, has been appointed Division Manager in charge of all operations on the West Coast. He will be assisted by T. J. Turek, Division Engineer, formerly Assistant Research Engineer at the factory in Elyria. Additional factory-trained sales, service and production personnel will complete the staff of the new plant which will be known as the Pacific Division of Bendix-Westinghouse.

Steven Speaks to Alfred Society

George S. Steven, executive engineer of the Worthington Pump and Machinery Corporation, Buffalo, N. Y., was the principal speaker recently at the first annual banquet of the Alfred Society of Diesel Technicians, an undergraduate professional society of the New York State Agricultural and Technical Institute at Alfred, N. Y.

In addressing the group of 75 which included guests from industry, faculty and students who attended the affair, Mr. Steven stated that although the

education of an engineering student is more or less specific, the student might be wiser to seek any type of employment, regardless of its nature, as "we are confronted, if not already involved, in a period of mild recession, when employment of any kind is becoming more difficult to obtain."

Superior Consultant

Appointment of F. H. Kilberry as management consultant in charge of the Superior Engine Division of The National Supply Company at Springfield, Ohio, has been announced. He will make his headquarters at Springfield and will be in charge of all activities of the division.

F. H. Kilberry

Identified with the diesel engine industry for more than 20 years, Mr. Kilberry until recently was executive vice president of Nordberg Manufacturing Company. From 1929 until 1945, he was associated with Atlas Imperial Diesel Engine Company serving that organization as president for six years.

Graver Appointment

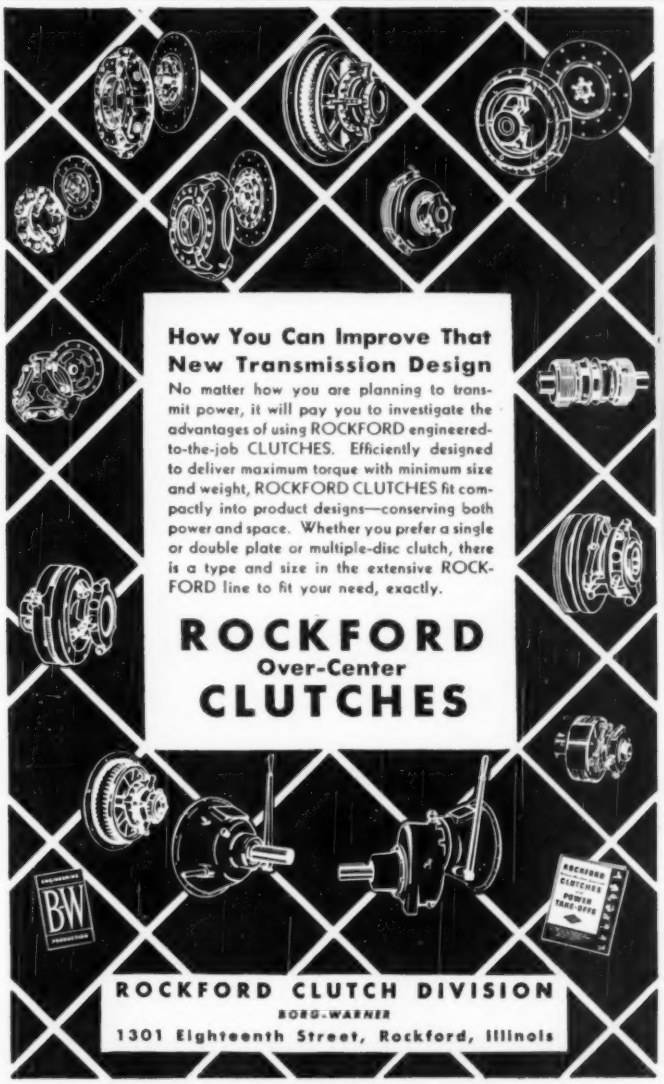
Graver Water Conditioning Co., Division of Graver Tank & Mfg. Co., Inc., manufacturers of equipment and materials for all water softening and liquid conditioning processes, announces the appointment of Tom Charbonneau as Florida representative.

Mr. Charbonneau has had extensive experience in this work. Following engineering courses in the Universities of Connecticut and Pennsylvania and special courses on water conditioning at the University of Florida, he devoted his attention to water conditioning problems in the southeastern states. For many years he has been engaged in sales and supervising work on treatment of boiler feed-water, consulting work on waste recovery, municipal water plants, etc., and he is a member of the American Water Works Association.

Cooper-Bessemer Directors

At the recent annual meeting, Cooper-Bessemer shareholders elected to membership on their Board of Directors Ralph L. Boyer and William E. Stevenson. Mr. Boyer is presently Vice President and Chief Engineer of Cooper-Bessemer. Mr. Stevenson is President of Oberlin College, Oberlin, Ohio.

Long recognized as a leading design authority in the diesel, gas engine and compressor fields, Mr. Boyer has been more recently associated with pioneer-


How You Can Improve That New Transmission Design
No matter how you are planning to transmit power, it will pay you to investigate the advantages of using ROCKFORD engineered-to-the-job CLUTCHES. Efficiently designed to deliver maximum torque with minimum size and weight, ROCKFORD CLUTCHES fit compactly into product designs—conserving both power and space. Whether you prefer a single or double plate or multiple-disc clutch, there is a type and size in the extensive ROCKFORD line to fit your need, exactly.
ROCKFORD
Over-Center
CLUTCHES
ROCKFORD CLUTCH DIVISION
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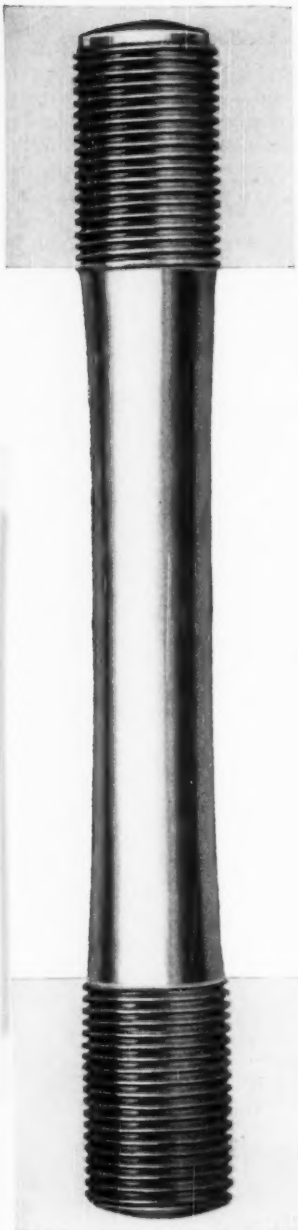
1301 Eighteenth Street, Rockford, Illinois



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STUDS • BOLTS • NUTS • ALLOY
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Representatives in all Principal Cities

Ralph L. Boyer

ing such notable developments as the gas-diesel or dual-fuel engine, Turbo-flow and the supercharging of 4-cycle spark-ignited gas engines. Graduate BME from Ohio State University in 1924, Mr. Boyer received his ME degree in 1930. He started his design career with Cooper-Bessemer in 1926 as diesel engineer, later to become Assistant Chief Engineer, then Chief Engineer until his election to Vice President and Chief Engineer in 1947.

The selection of Mr. Stevenson by Cooper-Bessemer shareholders was based on the valuable counsel that his background and experience can give to Cooper-Bessemer on various aspects of the company's business and particularly in the field of public relations.

A graduate of Princeton in 1922, Mr. Stevenson attended Oxford University in England as a Rhodes Scholar, there to receive his M.A. Degree in 1925. During World War II, he was awarded the Bronze Star Medal (U. S. Army) "for meritorious achievement in support of military operations" as American Red Cross delegate to Great Britain, North Africa and Italy. At present he is an active member of the President's Committee on Equality and Treatment of Opportunity in the Armed Services. He is also a member of the National Board of Directors of the English Speaking Union, New York.

Prior to his becoming President of Oberlin College in Oberlin, Ohio, Mr. Stevenson was a partner in the New York law firm of Debevoise, Stevenson, Plimpton & Page.

Naturally

IT'S MANZEL FORCE FEED LUBRICATION

in the New Alcoa Plant described in this issue

● In its huge new Port LaVaca plant the Aluminum Company of America has installed 120 Nordberg 1600 hp., eleven cylinder radial gas engines. Each of the engines is equipped with two 12 feed Manzel Model 82 Force Feed Lubricators . . . a total of 240 individually driven units.

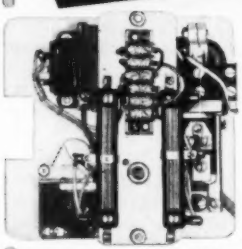
These Lubricators supply an accurately metered amount of oil to cylinders with unfailing regularity. They drastically reduce labor, maintenance, and overhead costs.

For the best in lubrication always call on . . .

Manzel
DIVISION OF
FRONTIER INDUSTRIES, Inc.
271 BABCOCK STREET, BUFFALO, N. Y.

Burlington Synchrostat

✓ LOW COST ✓ Dependable VOLTAGE REGULATOR



Interior view of Type SR-SF

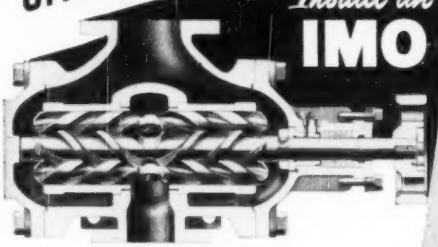
Generator Voltage Regulators For Portable Or Stationary Power Units

Burlington Regulators are available in various case styles for AC Power Units up to 25000 KW and DC up to 7500 KW.

Check Burlington quality and price before buying — Your inquiries for literature and engineering services solicited.

Burlington Instrument Co.
Dept. B-70
BURLINGTON, IOWA

PUMP SPACE LIMITED ? *Install an* IMO



● The capacity of the IMO is increased by high speed operation. This compact pump can be directly connected to the driving machine without bulky speed reduction gearing.

● IMO Pumps can be furnished for practically any capacity and pressure required for oil, hydraulic-control fluids and other liquids.

Send for Bulletin "I-146-EP"

IMO — I MOVE OIL

IMO PUMP DIVISION of the
DE LAVAL STEAM TURBINE CO.
TRENTON 2, NEW JERSEY

DIESEL USERS!

Here's how FRAM FILTERS can save you money . . .

Read these excerpts from the letter of a Fram user . . .

UNITED FISHERIES COMPANY
Distributors for Portuguese Note
401 MAIN STREET
GLOUCESTER, MASSACHUSETTS

November 15, 1948

Fram Corporation
Providence 16, R. I.

Gentlemen:

"I have installed Fram Filters on the lubricating and fuel systems of my fishing boat, 'Paul Howard.' Engine is rated at 425 horsepower.

"Before using Fram, engine and parts would get caked with sludge...often causing engine trouble.

"Now, I find oil and engine unusually clean. Fram Fuel Oil Filter removes dirt and scum before it reaches injection system.

"One set of cartridges good for 1000 to 1200 hours before oil starts to darken. Fram Filters have done a job far above my expectations. Pleased to recommend them."

Very truly yours,
UNITED FISHERIES VESSELS CO.
By:

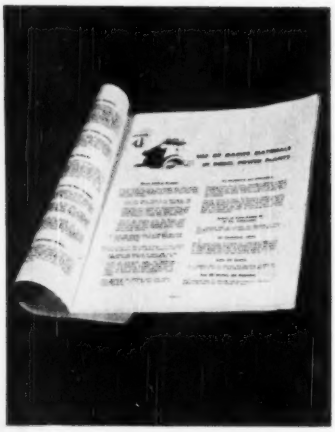
FRAM Can Help You!

No matter what your Diesel oil filtering problem—fuel or lube—Fram can help you conquer it. Let Fram's Research Department help you by determining what Fram Filcron Oil Filter you need for keeping injectors clean and efficient . . . keeping vital moving parts free from the damage caused by dirt, dust, grit, sludge and abrasives.

Save money, time on overhauls, breakdowns, the Fram Filcron way. Write today to Fram Corporation, Providence 16, R. I. *In Canada:* J. C. Adams Co., Ltd., Toronto, Ontario.

FRAM *Filcron*

THE MODERN OIL FILTER



FREE—

Your Guide to Faster Diesel Maintenance

THIS illustrated digest contains a wealth of sound, practical ideas to expedite Diesel maintenance and keep operating costs low. Gives details on such subjects as:

- Cleaning filters
- Desludging lube oil coolers
- Descaling jacket water coolers
- Degreasing engine parts before repair
- Steam-detergent cleaning
- Plant maintenance cleaning

Manual also discusses tested Oakite procedures for streamlining maintenance in steam control stations and electric power plants.

FREE copy of this 16-page digest yours on request. Consult your local Oakite Technical Service Representative. Or write address below. No obligation.

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OAKITE
SPECIALIZED INDUSTRIAL CLEANING
MATERIALS • METHODS • SERVICE

F-M Vice-Presidents

At a recent meeting of the Board of Directors of Fairbanks, Morse & Co., following their annual shareholders' meeting, two new Vice Presidents were elected. These are O. O. Lewis, Vice President in charge of Sales, and F. J. Heaslip, Vice President in charge of Purchases and Traffic.

Aeroquip Sales Engineer

Aeroquip Corporation announces that Mr. Byron E. Snow has been appointed Sales Engineer in the Chicago territory which embraces Illinois, Iowa, and Southeastern Wisconsin. Mr. Snow will service only the manufacturing accounts in that territory. His headquarters will be 330 Elizabeth Drive, Lombard, Illinois.

Falk Superintendent

Arthur H. Nolde has been appointed operating superintendent of The Falk Corporation machine shops it was announced recently by Harold F. Falk, vice president and works manager. In his new position, effective April 17, he serves as assistant to Ben C. Bugbee, machine shop superintendent.

Formerly Falk tool engineer, Nolde began his career with the company 23 years ago as a drafting apprentice. Last year he was chairman of the Standards Committee of The American Society of Tool Engineers.

Alco Director

Appointment of Herman Press, treasurer of American Locomotive Company, as a Director has been announced by the Board of Directors.

Mr. Press has been associated with American Locomotive since 1929 when he was appointed assistant to the president. He was named treasurer in 1937.

Mr. Press is a director of the Blackstone Mutual Fire Insurance Company of Providence, R. I. He is treasurer and director of American Locomotive Export Company, Inc.; director, member of the executive committee and treasurer of Beaumont Iron Works, and treasurer and director of Montreal Locomotive Works, Ltd. He is also a director of the Nathan Manufacturing Company of New York.

OUR HOSE *is always* SHOWING

Look at a Diesel. The flexible metallic hose you see is very likely by ATLANTIC. Whatever the Diesel application — marine, automotive, rail or for stationary service — ATLANTIC FLEXIBLE METAL HOSE is in there doing its iob.

DOUBLE INSULATED EXHAUST HOSE is designed to prevent heat radiation where hose passes through inhabited quarters . . . Type A-1 is best for Fuel Oil Lines, Lube Oil Lines, Water Lines, Air Lines . . . Type SW is an all-purpose exhaust hose famous for flexibility of use and construction. WATER JACKETED HOSE answers extraordinary exhaust problems.

Made of bronze, steel or stainless steel as specified. Sizes ⅛"—36" I.D. inclusive. Standard or special couplings, flanges, nipples and fittings.

Our DIESEL BULLETINS 1020 and 50A supply complete information.

ATLANTIC
METAL HOSE CO., INC.
109 West 64th St., New York 23, N. Y.

NEED TRAINED DIESEL MEN?

Hemphill graduates have received broad, practical training in the operation, maintenance, and servicing of diesel engines.

On your job they can save you money, and make you money.

GET THE KIND OF DIESEL MEN YOU NEED FROM

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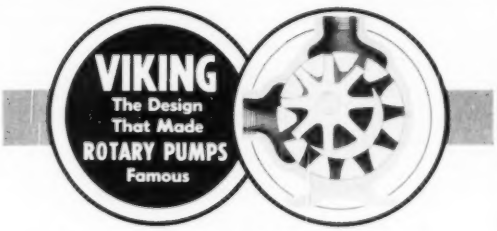

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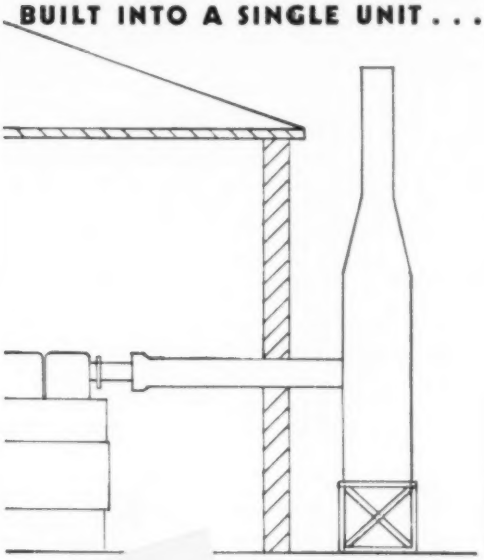

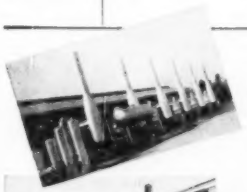

A single silencer outside and only the exhaust piping inside — a space saving installation — and a flexible one because exhaust can be run high, low, or underground with the Maxim Air Induction Silencer. The inlet can be placed where you want it. Hot air is drawn out of the engine room, and piping and silencer are both cool so that paint will stay on. Investigate this *most practical* way to get adequate silencing and engine room ventilation.

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Allegheny Ludlum Director

Joseph A. Martino, President of National Lead Company, has been elected to the Board of Directors of Allegheny Ludlum Steel Corporation. The two companies recently announced formation of Titanium Metals Corporation of America, a jointly owned company, organized for the development, sale and distribution of titanium metal, its alloys and allied products.

Mr. Martino, yet to celebrate his fiftieth birthday, began his career with National Lead in 1916, getting his education by attending night courses at Columbia University. Rising through the ranks, he was elevated to vice president in 1944 after serving for several years as controller and was elected president three years later.

G-E Appointments

C. C. Clymer has been appointed Manager, Materials Handling & Testing Equipment Division of General Electric's Industrial Engineering Divisions according to an announcement by J. D. Wright, divisions' manager. Clymer is replacing M. A. de Ferranti, who has been appointed assistant to A. W. Jacobsen, Manager, Parts Division, Aircraft Gas Turbine Divisions.

Koppers Engineering Aide

Earl V. Harlow has been appointed Engineering Assistant to Walter F. Perkins, vice president and general manager of the Metal Products Division of Koppers Company, Inc.

Formerly associated with Koppers central Research Department, Mr. Harlow in his new assignment will be responsible for assisting and advising the Division General Manager on engineering matters, and for coordinating research and development projects between the Division and the Research Department.

Mr. Harlow joined Koppers as a draftsman in 1926 and two years later became associated with the Company's Research Department. From 1942 to 1946 he was chief process engineer at the Kobuta styrene and butadiene plant which Koppers built and operated for the U. S. Office of Rubber Reserve. Since 1946 Mr. Harlow has been engaged in research activities at the Seaboard Experimental Station of the Research Department in Kearny, N. J.

Cooper-Bessemer Consultant

As a step in an expanded program of market analysis, product development and diversification, The Cooper-Bessemer Corporation has just engaged the full-time services of consultant Robert P. Ramsey, recognized authority on industrial market research and product design. Mr. Ramsey recently became an independent consultant following 10 years of work with the Lima-Hamilton Corporation, H.O.R. Division, where, as Vice President of Engineering and Chairman of the Lima-Hamilton engineering committee, he was responsible for the development of a wide line of industrial equipment such as canning machinery, body presses, locomotives, power shovels, heavy machine tools and internal combustion engines.

Robert P. Ramsey

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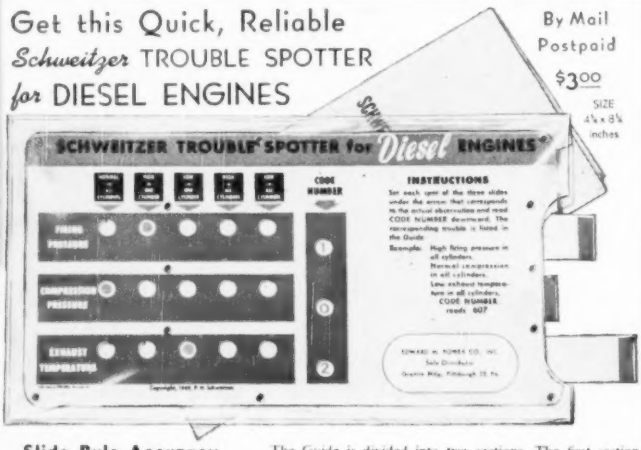

Slide Rule Accuracy

This guide prepared by Paul H. Schweitzer, Dr. Eng. Penna. State College in collaboration with Diesel Engine experts enables operators and service men to locate and remedy troubles encountered in Diesel engine operation. Makes trouble spotting an easy semi-automatic process, and points unerringly to the proper remedy, thus saving a great amount of time and expense. The guide is snugly encased in stout plastic jacket.

The Guide is divided into two sections. The first section is entitled TROUBLE and it lists the code numbers for various observations, each with the corresponding trouble or troubles.

The second section is entitled DEFECTS and it deals with the origin of the various troubles.

The two sections are interlocked through a unique numbering system, which makes the use of the Guide extremely convenient.

The TROUBLE section carries code numbers in the left side column. These numerals correspond to those of the Trouble Spotter, attached to this booklet.

The second column lists suplementary observations which help to diagnose the trouble or to select the correct one if one code number allows more than one.

The third column lists the probable troubles corresponding to their code numbers.

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Socony-Vacuum Change

H. H. Moore has been made sales manager of Socony-Vacuum Oil Company's White Eagle Division, Kansas City, Mo., succeeding the late Charles A. Lewers. E. B. Kendrick has been made the assistant sales manager.

Hunt-Spiller V.P.

A. J. Edgar, general manager of Hunt-Spiller Mfg. Corp., Boston, producers of railroad, marine, and stationary diesel castings, has been elected a vice president, Neil C. Raymond, president of the 140-year-old company, has announced.

GM Managers

Appointment of Mr. R. L. Terrell to be Assistant Regional Manager, New York Region, and of Mr. Marvin Anderson to be General Parts Manager of Electro-Motive Division of General Motors is announced by Mr. N. C. Dezendorf, Director of Sales. The appointments are effective April 1.

Mr. Terrell has been General Parts Manager since October 1, 1948. He was born in Dayton, Ohio, in 1918 and received his preparatory education there. He has been with General Motors Corporation ever since 1936.

Mr. Anderson has been Assistant General Parts Manager since October 1, 1948. Educated in Springfield, Missouri public schools and at Drury College, Mr. Anderson had wide ex-

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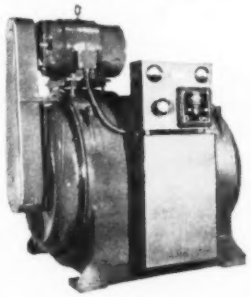

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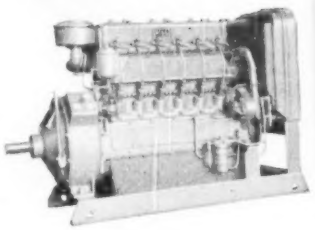

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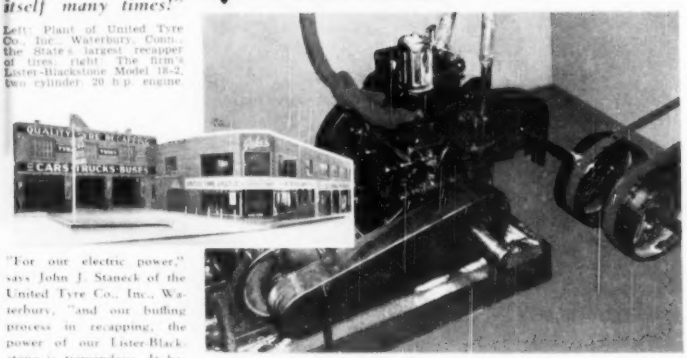

Left: Plant of United Tyre Co., Inc., Waterbury, Conn., the State's largest recapper of tires, right: The firm's Lister-Blackstone Model 18-2, two cylinder, 20 h.p. engine.

"For our electric power," says John J. Staneck of the United Tyre Co., Inc., Waterbury, "and our buffing process in recapping, the power of our Lister-Blackstone is tremendous. It has paid for itself many times; our expenses are far less than ordinary." The engine, in daily use since 1939, has never had a breakdown.

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perience in the storage and issue of many kinds of merchandise from 1925 to 1936. In the latter year he joined General Motors.

Nordberg Changes

Mr. James A. Friend has been appointed Senior Vice-President of Nordberg Manufacturing Company according to an announcement by Robert E. Friend, President. Mr. James Friend, former Vice-President and General Purchasing Agent, will take over the duties of F. Howard Kilberry who resigned to become a Management Consultant in charge of the

James A. Friend

Superior Engine Division of the National Supply Company.

Mr. Floyd T. Finley has been appointed General Purchasing Agent of the Milwaukee Division of Nordberg to succeed James Friend. It is also announced that D. A. Cheyette, Vice-President of the Crusher Division, has been elected to Nordberg's Board of Directors. Mr. Aruthur W. Mueller was appointed Assistant Controller of the company.

Nordberg Promotion

Mr. Carl O. Friend, Sales Research Manager of the Nordberg Manufacturing Co. has announced that effective June 1, Mr. Jack D. Grace will be in charge of advertising and publicity activities at Nordberg. Mr. Grace will succeed Mr. Delbert Kay as advertising manager. Mr. Kay has planned his retirement later this year and will be engaged in field work gathering data for use primarily in Nordberg advertising and publicity.

National Carbon President

J. M. Spangler, former Director, Vice-President and General Manager of the National Carbon Division of Union Carbide and Carbon Corporation, now has been appointed President of the Division after thirty-five years of service.

Mr. Spangler has for years been well known in automotive and electrical circles through his activities in the sale of "Prestone" anti-freeze and "Eveready" flashlights and batteries. In taking over his new position, Mr. Spangler takes charge of a nation-wide organization.

A-C Change

William G. Lewis was named assistant to L. W. Long, general manager of Allis-Chalmers Boston Works, effective March 15.

Lewis, a graduate of Northeastern University, became associated with Boston Works in 1926. He has been assistant engineer-in-charge of circuit breaker sales.

Alfred E. Kilgour succeeds Lewis as assistant engineer-in-charge of circuit breaker sales. He started with the company's switchgear division in 1942 as an application engineer and was transferred to the Boston Works in November, 1947.

Cooling

(*Concluded from page 51*)

An important consideration in award of the fluid cooler contract to the Trane Company was the company's quarter of a century of experience in designing, fabricating and testing performance of the various types of fin and tube coils employed in heat exchangers, heating coils, convectors, cooling coils, condensers, unit heaters and similar equipment.

Trane's Plant 6 underwent a minor remodeling to handle the six months job of producing the Point Comfort fluid coolers. A special large door and loading dock were necessary to handle the large casings and plenum chambers.

The entire order required 52 freight cars for shipment, and consumed half a million pounds of aluminum tubing, sheets and strips. Material used included 2,790,000 feet of aluminum fin material, 736,320 feet of aluminum tubing.

Casings, coils, fans and plenum chambers were shipped separately to Port Lavaca and assembled on the job.

Reports from the plant engineering staff indicate that the cooling system is performing to full specifications.

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2—New 37½ kva 220/440 v. 3 ph 60 cy. Le Roi Gas or Gasoline.
1—25 kw 120/208 v. 3 ph 60 cy. Le Roi Gasoline.
1—75 kva 220/440 v. 3 ph 60 Internat'l Gasoline.
10—New 25 kva 110/220 v. 1 ph 60 cy. Le Roi Gas or Gasoline.
2—30 kw. 220/440 v. 3 hp. 60 cy. Century-Buda Diesels.
1—10 kw. 220/440 v. 3 ph. 60 cy. Hercules GASOLINE.
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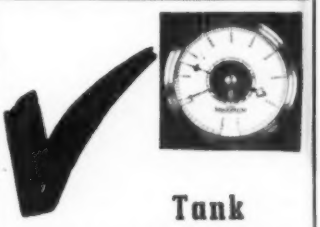

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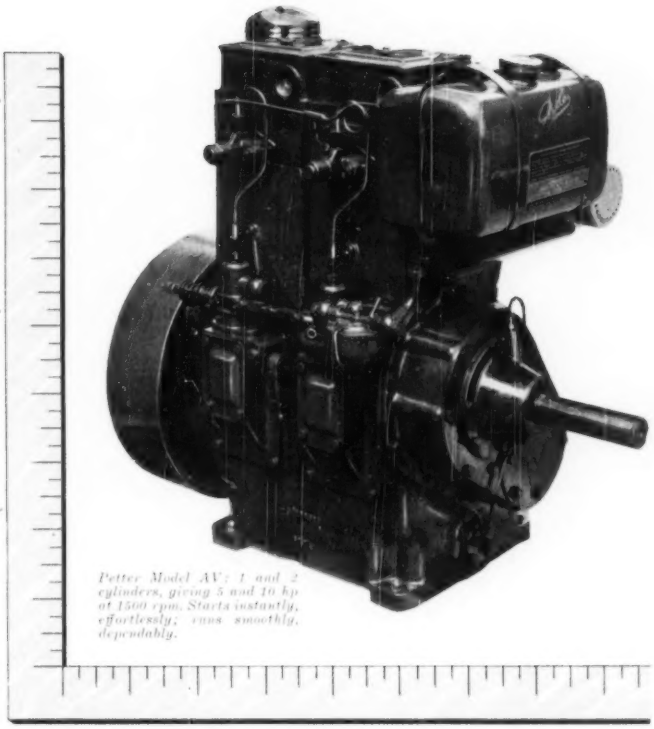
All over the world, Petter Diesels are noted for their dependability and long life. They are ruggedly built; direct injection; 4-cycle operation. Drive can be taken at full speed from either end of crankshaft, or at half-speed from camshaft. Petter Diesels require a minimum of maintenance, make for greater customer satisfaction.



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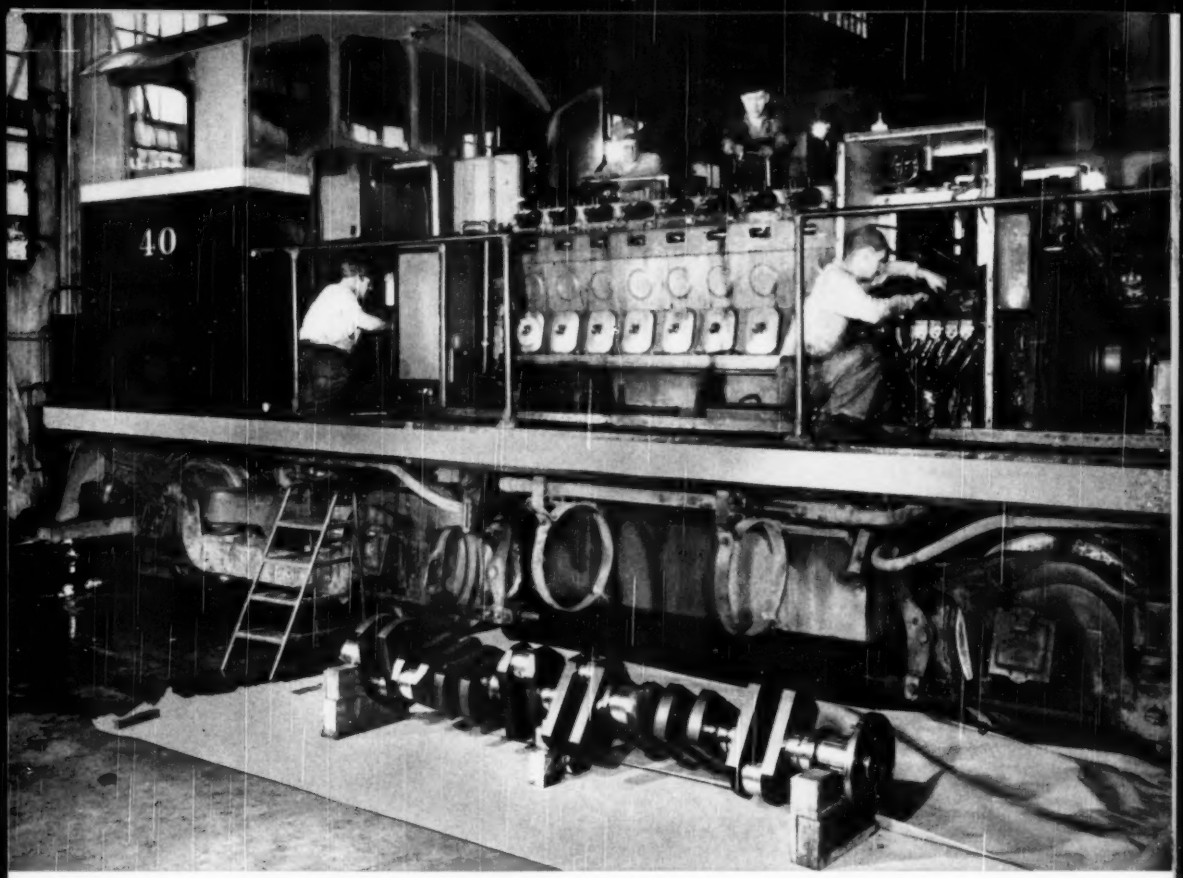

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